PB-224 589

# RECOMMENDED METHODS OF REDUCTION, NEUTRALIZATION, RECOVERY, OR DISPOSAL OF HAZARDOUS WASTE

## VOLUME X. INDUSTRIAL AND MUNICIPAL DISPOSAL CANDIDATE WASTE STREAM CONSTITUENT PROFILE REPORTS. ORGANIC COMPOUNDS

TRW Systems Group

PREPARED FOR
Environmental Protection Agency

August 1973

Distributed By:
NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

PB 224 589

BIBLIOGRAPHIC DATA SHEET

1. Report No. EPA-670/2-73-053-j

2.

4. Title and Subtitle Recommended Methods of Reduction, Neutralization, Recovery, or Disposal of Hazardous Waste. Volume X, Industrial and Municipal Disposal Candidate Waste Stream Constituent Profile Reports - Organic Compounds

5. Report Date Issuing date - Aug 1973

6.

7. Author(s) R. S. Ottinger, J. L. Blumenthal, D. F. Dal Porto, G. I. Gruber, M. J. Santy, and C. C. Shin

8. Performing Organization Rept. No. 21485-6013-RU-00

9. Performing Organization Name and Address

TRW Systems Group, One Space Park
Redondo Beach, California 90278

10. Project/Task/Work Unit No.

11. Contract/Grant No. 68-03-0089

12. Sponsoring Organization Name and Address
National Environmental Research Center
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

13. Type of Report & Period Covered Final

14.

15. Supplementary Notes

Volume X of 16 volumes.

16. Abstracts

This volume contains summary information and evaluation of waste management methods in the form of Profile Reports for organic compounds. These Profile Reports were prepared for either a particular hazardous waste stream constituent or a group of related constituents. Each Profile Report contains a discussion of the waste stream constituents, their toxicology and other associated hazards, the definition of adequate management for the waste material, an evaluation of the current waste management practices with regard to their adequacy, and recommendation as to the most appropriate processing methods available and whether the waste material should be considered as a candidate for National Disposal, Industrial Disposal, or Municipal Disposal.

17. Key Words and Document Analysis. 17a. Descriptors

Organic Compounds
Industrial Disposal Candidate
Municipal Disposal Candidate
Hazardous Wastes
Aliphatic and Aromatic Carbonyl Compounds and Derivatives
Aliphatic Hydrocarbons
Carboxylic Acids
Alcohols
Aliphatic Amines
Esters
Aliphatic Halogenated Hydrocarbons

17b. Identifiers/Open-Ended Terms

NATIONAL TECHNICAL
INFORMATION SERVICE

17c. COSATI Field/Group 06F; 06T; 07B; 07C; 07E; 13B; 13H; 19A; 19B

18. Availability Statement

Release to public.

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

21. No. of Pages

22. Price

EPA-670/2-73-053-j
August 1973

# RECOMMENDED METHODS OF REDUCTION, NEUTRALIZATION, RECOVERY OR DISPOSAL OF HAZARDOUS WASTE

## Volume X. Industrial and Municipal Disposal Candidate Waste Stream Constituent Profile Reports - Organic Compounds

By

R. S. Ottinger, J. L. Blumenthal, D. F. Dal Porto,
G. I. Gruber, M. J. Santy, and C. C. Shih
TRW Systems Group
One Space Park
Redondo Beach, California 90278

Contract No. 68-03-0089
Program Element No. 1D2311

Project Officers

Norbert B. Schomaker
Henry Johnson
Solid and Hazardous Waste Research Laboratory
National Environmental Research Center
Cincinnati, Ohio 45268

Prepared for
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

# REVIEW NOTICE

The Solid Waste Research Laboratory of the National Environmental Research Center - Cincinnati, U.S. Environmental Protection Agency has reviewed this report and approved its publication. Approval does not signify that the contents necessarily reflect the views and policies of this Laboratory or of the U.S. Environmental Protection Agency, nor does mention of trade names of commercial products constitute endorsement or recommendation for use.

The text of this report is reproduced by the National Environmental Research Center - Cincinnati in the form received from the Grantee; new preliminary pages and new page numbers have been supplied.

# FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multidisciplinary focus through programs engaged in:

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

Under Section 212 of Public Law 91-512, the Resource Recovery Act of 1970, the U.S. Environmental Protection Agency is charged with preparing a comprehensive report and plan for the creation of a system of National Disposal Sites for the storage and disposal of hazardous wastes. The overall program is being directed jointly by the Solid and Hazardous Waste Research Laboratory, Office of Research and Development, National Environmental Research Center, Cincinnati, and the Office of Solid Waste Management Programs, Office of Hazardous Materials Control. Section 212 mandates, in part, that recommended methods of reduction, neutralization, recovery, or disposal of the materials be determined. This determination effort has been completed and prepared into this 16-volume study. The 16 volumes consist of profile reports summarizing the definition of adequate waste management and evaluation of waste management practices for over 500 hazardous materials. In addition to summarizing the definition and evaluation efforts, these reports also serve to designate a material as a candidate for a National Disposal Site, if the material meets criteria based on quantity, degree of hazard, and difficulty of disposal. Those materials which are hazardous but not designated as candidates for National Disposal Sites, are then designated as candidates for the industrial or municipal disposal sites.

A. W. Breidenbach, Ph.D., Director
National Environmental Research Center
Cincinnati, Ohio

# TABLE OF CONTENTS

## VOLUME X

## INDUSTRIAL AND MUNICIPAL DISPOSAL CANDIDATE WASTE STREAM CONSTITUENT PROFILE REPORTS

### Organic Compounds

Page

Acetaldehyde (1), Acetone (4), Butyraldehyde (79), Camphor (96), Crotonaldehyde (126), Cyclohexanone (133), Diisobutyl Ketone (157), Ethyl Methyl Ketone (193), Furfural (203), Isophorone (226), Mesityl Oxide (259), Methyl Isobutyl Ketone (271), Paraformaldehyde (320), Propionaldehyde (355) . . . . . 1

ALIPHATIC AND AROMATIC CARBONYL COMPOUNDS AND DERIVATIVES - Acetic Acid (2), Acetic Anhydride (3), Acetyl Chloride (9), Formaldehyde (201), Oleic Acid (316), Phthalic Anhydride (337), Sodium Formate (390), Sodium Oxalate (398). . . . . . . . . . . . . . 21

Acetone Cyanohydrin (5), Acetonitrile (6), Acrylonitrile (11), Cyanoacetic Acid (130), Ethylene Cyanohydrin (183), Toluene Diisocyanate (511) . . . . . . . . . . . . . . . . . . . . . . . 41

ALIPHATIC HYDROCARBONS - Acetylene (7), Butadiene (68), Butane (69), 1-butene (71), Butylene (76), Cyclohexane (131), Dicyclopentadiene (148), Diisobutylene (156), Ethane (493), Ethylene (181), n-Heptane (207), 1-Heptene (208), Hexane (211), Isopentane (225), Isoprene (227), Naphtha (crude) (284), n-Pentane (323), Propane (354), Propylene (360), Tetrapropylene (429), Tripropane (Norene)446), Turpentine (447), AROMATIC HYDROCARBONS - Anthracene (466), Benzene (54), Creosote (coal tar) (123), Cumene (127), Dodecylbenzene (169), Ethylbenzene (179) Naphthalene (285), Styrene (412), Toluene (434), Xylene (451) . . . . 55

CARBOXYLIC ACIDS - Acrylic Acid (10), Adipic Acid (12), Benzoic Acid (57), Fatty Acids (197), Formic Acid (202), Propionic Acid (356), Salicylic Acid (366). . . . . . . . . . . . . . . . . . . . 101

ALCOHOLS - Allyl Alcohol (14), Amyl Alcohol (31), Butanols (70, 74,498), Cyclohexanol (132), Decyl Alcohol (138), Diethylene Glycol (154), Dipropylene Glycol (168), Ethanol (172), Ethylene Glycol (186,206), Furfural Alcohol (204), Glycerine (205), Isopropanol (228), Methanol (261), Methyl Amyl Alcohol (266), Octyl Alcohol (191), n-Propyl Alcohol (358), Propylene Glycol (361), Sorbitol (407), Triethylene Glycol (443). . . 115

Preceding page blank

TABLE OF CONTENTS (CONTINUED)

Page

Allyl Chloride (15) . . . . . . . . . . . . . . . . . . . . . . . . . 147

ALIPHATIC AMINES - Aminoethylethanol Amine (18), n-Butylamine (75), Cyclohexylamine (134), Diethanolamine (150), Diethylamine (151), Diethylene Trimine (155), Diisopropanolamine (158), Dimethylamine (159), Ethanolamine (Monoethanolamine) (173,279), Ethylamine (Monoethylamine) (178), Ethylene Diamine (184), Hexamethylene Diamine (210), Isopropyl Amine (231), Methylamine (265), Morpholine (281), Propylamine (359), Triethanolamine (441), Triethylamine (442), Triethylene Tetramine (444), Trimethylamine (445), Urea (448) . . . . . . . . . . . . . . . . . . . . . . . 155

ESTERS - Amyl Acetate (30), Butyl Acetate (72), Butyl Acrylate (73), Di-n-butyl Phthalate (139), Ethyl Acetate (175), Ethyl Acrylate (176), Ethyl Phthalate (194), Isobutyl Acetate (224), Isopropyl Acetate (229), Methyl Acetate (262), Methyl Acrylate (263), Methyl Formate (270), Methyl Methacrylate (273), n-Propyl Acetate (357), Vinyl Acetate (449). . . . . . . . . . . . . . . . . 187

Acridine (464), Aniline (32), 2,4-Dinitroaniline (161), n-Methylaniline (280), -Naphthylamine (286), Phenylhydrazine Hydrochloride (328), Pyridine (364), o-Toluidine (435) . . . . . . . . . 213

Benzene Sulfonic Acid (56). . . . . . . . . . . . . . . . . . . . . 231

Benzyl Chloride (58). . . . . . . . . . . . . . . . . . . . . . . . 237

Butyl Phenol (78), Carbolic Acids (Phenol) (97,327), Cresol (Cresylic Acid) (124,125), Diethylstibestrol (492), Ethyl Phenol (196), Nonyl Phenol (314), Xylenol (452) . . . . . . . . . . . . . . . . . . 245

Butyl Mercaptan (77), Ethyl Mercaptan (192), Methyl Mercaptan (272) . 263

Carbon Disulfide (98) . . . . . . . . . . . . . . . . . . . . . . . 275

ALIPHATIC HALOGENATED HYDROCARBONS - Carbon Tetrachloride (100), Chloral Hydrate (104), Chloroform (109), Dichloroethyl Ether (143), Dichlorofluoromethane (142), Dichloromethane (144), 1,2-Dichloropropane (145,363), 1-3-Dichloropropene (146), Dichlorotetrafluoroethane (147), Epichlorohydrin (171), Ethyl Chloride (180), Ethylene Dichloride (185), Methyl Chloroformate (269), Perchloroethylene (325), Polyvinyl Chloride (340), Tetrachloroethane (424), Trichloroethane (437), Trichlorofluoromethane (439), Vinyl Chloride (450), AROMATIC HALOGENATED HYDROCARBONS - Chlorobenzene (Chlorobenzol) (108), -Dichlorobenzene (140,278), -Dichlorobenzene (141), Hexachlorophene (497), Trichlorobenzene (436) . . . . . . . . . . 283

# PROFILE REPORT

Acetaldehyde (1), Acetone (4), Butyraldehyde (79), Camphor (96), Crotonaldehyde (126), Cyclohexanone (133), Diisobutyl Ketone (157), Ethyl Methyl Ketone (193), Furfural (203), Isophorone (226), Mesityl Oxide (259), Methyl Isobutyl Ketone (271), Paraformaldehyde (320), Propionaldehyde (355).

## 1. GENERAL

### Introduction

The aliphatic carbonyl compounds treated in this report have all been selected as probable candidate waste stream constituents for municipal disposal. These materials are similar in that most are commodity chemicals with relatively low toxicity, well-defined and safe methods of industrial handling and common methods of disposal. The aliphatic carbonyl compounds are, therefore, discussed as a class in this report.

### Manufacture and Use

These aliphatic aldehydes and ketones are manufactured by a variety of industrial processes. In general, the synthetic routes employed involve some form of catalytic oxidation or dehydration of the corresponding alcohol. They are used as solvents and/or intermediates in the manufacture of chemicals and synthetic resins. Some (e.g., furfural and isophorone) are themselves components of important commercial polymers.

### Physical and Chemical Properties

The physical and chemical properties of the compounds discussed in this report are included in the attached worksheets.

## 2. TOXICOLOGY[0766]

As a group, the aliphatic carbonyl compounds possess narcotic and anesthetic properties, but this is obscured in many cases by their highl irritating action on the eyes and the mucous membranes of the respiratory tract. The more volatile compounds which are very soluble in water act chiefly on the eyes and tissues of the upper respiratory tract, while the less volatile and water soluble compounds tend to penetrate more deeply into the respiratory system and may affect the lungs. These effects range from slight, as in the case of acetone, to substantial, as in the case of the unsaturated aldehydes and ketones such as crotonaldehyde, furfural, isophorone and mesityl oxide. In general, the danger parallels the Threshold Limit Values (TLV) that have been established for these materials. Ingestion, aside from its irritating effect, causes nausea, vomiting, headache, and dizziness. None of these compounds has been shown to have a high degree of chronic toxicity except for the unsaturated aldehydes and ketones which may be dangerous to the kidneys, liver and lungs.

The Threshold Limit Values and Maximum Allowable Concentrations (MAC) that have been established are:

| Substance | TLV ppm | TLV mg/M$^3$ | MAC ppm |
|---|---|---|---|
| Acetaldehyde | 100 | 180 | 200 |
| Acetone | 1000 | 2400 | 1000 |
| Butyraldehyde | - | - | - |
| Camphor | 2 | 12 | - |
| Crotonaldehyde | 2 | 6 | - |
| Cyclohexanone | 50 | 200 | 50 |
| Diisobutyl Ketone | 25 | 150 | 50 |
| Ethyl Methyl Ketone | 200 | 590 | 250 |
| Furfural | 5 | 20 | 5 |
| Isophorone | 10 | 55 | - |
| Mesityl Oxide | 25 | 100 | 25 |
| Methyl Isobutyl Ketone | 100 | 410 | 100 |
| Paraformaldehyde | - | - | - |
| Propinaldehyde | - | - | - |

## 3. OTHER HAZARDS

All of these materials must be considered as potential fire hazards. The severity of the threat they pose increases with decreasing boiling point; the precise values for their flash points and other pertinent data may be found in the attached worksheets.

## 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

### Handling, Storage and Transportation

The aliphatic carbonyl compounds treated in this report are all toxic to a certain extent due to the narcotic effects of high concentrations and irritating effects of the liquids or vapors, especially in the sensitive areas of the eyes, mucous membranes and respiratory tract. Thus, they should be handled in a well-ventilated area and protective clothing and respirators are recommended where necessary. In cases of accidental contact, all contaminated clothing should be removed and the skin washed thoroughly with soap and water.

These materials are shipped under a variety of U.S. Department of Transportation (DOT), U.S. Coast Guard and IATA regulations. Most regulations relate to the flammability of these compounds. Information on safe handling and use of these compounds can be found in standard reference sources or manufacturers' Technical Data Sheets.

### Disposal/Reuse

Manufacturers who use these aldehydes and ketones as chemical intermediates or process solvents recycle as much material as possible. However, a substantial amount of the compounds in this group are used to produce resins or plastics and are generally not recoverable from these applications.

Many of the various manufacturing processes result in dilute waste streams which have a high chemical and biological oxygen demand.[0285,1543] They can be treated on-site or discharged into the municipal sewers.

Recommended provisional limits for the subject aliphatic carbonyl compounds are listed below:

| Contaminant in Air | Provisional Limit | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M$^3$ | |
| Acetaldehyde | 1.0 | 1.8 | 0.01 TLV |
| Acetone | 10 | 24 | 0.01 TLV |
| Butyraldehyde | - | 0.1 | Based on similar compounds |
| Camphor | 0.02 | 0.12 | 0.01 TLV |
| Crotonaldehyde | 0.02 | 0.06 | 0.01 TLV |
| Cyclohexanone | 0.50 | 2.0 | 0.01 TLV |
| Diisobutyl Ketone | 0.25 | 1.5 | 0.01 TLV |
| Ethyl Methyl Ketone | 2 | 5.9 | 0.01 TLV |
| Furfural | 0.05 | 0.20 | 0.01 TLV |
| Isophorone | 0.10 | 0.55 | 0.01 TLV |
| Mesityl Oxide | 0.25 | 1.0 | 0.01 TLV |
| Methyl Isobutyl Ketone | 1 | 4.1 | 0.01 TLV |
| Paraformaldehyde | - | 0.06 | Based on similar compounds |
| Propinaldehyde | - | 0.1 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limit ppm (mg/l) | Basis for Recommendation |
|---|---|---|
| Acetaldehyde | 9.0 | Stokinger and Woodward Method |
| Acetone | 60.0 | Stokinger and Woodward Method |
| Butyraldehyde | 0.5 | Based on similar compounds |
| Camphor | 0.6 | Stokinger and Woodward Method |
| Crotonaldehyde | 0.30 | Stokinger and Woodward Method |
| Cyclohexanone | 10.0 | Stokinger and Woodward Method |
| Diisobutyl Ketone | 7.5 | Stokinger and Woodward Method |
| Ethyl Methyl Ketone | 29.5 | Stokinger and Woodward Method |
| Furfural | 1.0 | Stokinger and Woodward Method |
| Isophorone | 2.75 | Stokinger and Woodward Method |
| Mesityl Oxide | 5.0 | Stokinger and Woodward Method |
| Methyl Isobutyl Ketone | 20.5 | Stokinger and Woodward Method |
| Paraformaldehyde | 0.15 | Based on similar compounds |
| Propionaldehyde | 0.5 | Based on similar compounds |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No. 1 - Recycling

Manufacturers that use these materials as chemical intermediates or process solvents recycle as much material as possible. In addition, a certain amount of contaminated material may be reprocessed. This is the method of choice wherever possible.

### Option No. 2 - Treatment of Waste Water to Reduce Chemical and Biological Oxygen Demand

Aldehydes and ketones treated in this report not only have a low level of toxicity but they can be biodegraded very rapidly by unacclimated activated sludges.[1543] This is due in part to the fact that they can, in most cases, be simply oxidized by chemical or biological means to acids that are the same or very similar to carboxylic acids present in normal sewage.

Thus, an acceptable method of disposal is via municipal sewage treatment plants, provided the rate of discharge is uniform.

### Option No. 3 - Incineration

Bulk quantities of contaminated aliphatic aldehydes and ketones that can not be reprocessed or released by controlled dilution can best be disposed of by incineration. This is the method of choice where adequate biological treatment facilities are not available.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

All of the wastes generated by the industries that produce and use the materials discussed in this report can be treated by common industrial and municipal methods such as incineration and sewage treatment processes. Therefore, the aliphatic carbonyl compounds discussed in this report are not judged to be candidate waste stream constituents for National Disposal Site treatment.

# 7. REFERENCES

0285 Lund, H.F., ed. Industrial pollution control handbook. New York, McGraw-Hill Book Company, 1971. 843 p.

0766 Sax, I.R., Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1492 The Merck index of chemicals and drugs. 7th ed. Rahway, New Jersey, Merck Company, Inc., 1960. 1,634 p.

1543 Ludzack, F.J., M.B. Ettinger. Chemical structures resistant to aerobic chemical stabilization. Journal Water Pollution Control Federation, 32(11):1173-1200, Nov. 1960.

1570 Weast, E.C., ed. Handbook of chemistry and physics. 48th ed. Cleveland, Ohio, Chemical Rubber Company, 1969. 2,100 p.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Acetaldehyde (1)

IUC Name ethanol

Common Names acetic aldehyde, ethyl aldehyde

Structural Formula

$CH_3$-CHO

Molecular wt. 44.05 Melting Pt. -123.5 C(1) Boiling Pt. 20.8 C(1)

Density (Condensed) 0.7827 @ 20/20 C(1) Density (gas) 1.52(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point -36 F (C.C.)(1) Autoignition Temp. 365 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 4.0%(1) Upper 57%(1)

Solubility

Cold Water miscible(2) Hot Water Ethanol miscible(2)

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid, red label Coast Guard Classification red label

Comments

References (1) 0766
(2) 1492

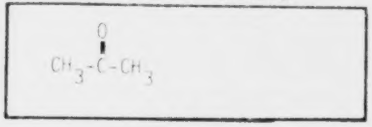
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Acetone (4)

IUC Name 2-propanal

Common Names dimethyl ketone, propanone

Structural Formula



$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$

Molecular wt. 58.08 Melting Pt. -94.6 C(1) Boiling Pt. 56.48 C(1)

Density (Condensed) 0.7972 @ 15 C(1) Density (gas) 2.00(1) @

Vapor Pressure (recommended 55 C and 20 C)

400 mm @ 39.5 C(1) @ @

Flash Point 0 F (C.C.)(1) Autoignition Temp. 1000 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.6%(1) Upper 12.8%(1)

Solubility

Cold water miscible(2) Hot water Ethanol miscible(2)

Others: miscible DMF, chloroform, ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid, red label Coast Guard Classification red label

Comments MCA warning label

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butyraldehyde (79)

IUC Name 1-butanal

Common Names n-butyl aldehyde

Structural Formula

$CH_3-CH_2-CH_2-CHO$

Molecular wt. 72.1 Melting Pt. -100 C(1) Boiling Pt. 75.7 C(1)

Density (Condensed) 0.817 @ 20/4 C(1) Density (gas) 2.5(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 20 F (C.C.)(1) Autoignition Temp. 446 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water Ethanol

Others: miscible ethyl acetate, acetone, many other organic solvents.(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid, red label Coast Guard Classification red label

Comments MCA warning label

References (1) 0766

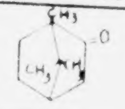
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Camphor (96)

IUC Name

Common Names 2-camphonone, gum camphor, laurel camphor

Structural Formula



Molecular wt. 152.23 Melting Pt. 174-177 C(1) Boiling Pt. 204 C(1)

Density (Condensed) 0.992 @ 25/4 C(1) Density (gas) 5.24(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 150 F (C.C.)(1) Autoignition Temp. 871 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 0.6%(1) Upper 3.5%(1)

Solubility

Cold water 1 g/800 ml at 25 C(2) Hot water Ethanol very soluble(2)

Others: soluble chloroform, benzene, acetone, acetic acid, and most other common solvents.(2)

Acid, Base Properties

Highly Reactive with $KMnO_4$

Compatible with

Shipped in

IUC Classification Coast Guard Classification Hazardous article

Comments sublimes at room temperature and atmospheric pressure.(2)

References (1) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Crotonaldehyde (126)

IUC Name 2-butenal

Common Names crotonic aldehyde, β-methylacrolein

Structural Formula

$CH_3$-CH=CH-CHO

Molecular wt 70.09 Melting Pt.

Density (Condensed) 0.853 @ 20/20 C(1) Density (gas) 2.41(1) @ Boiling Pt. 104 C(1)

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 55 F(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.1%(1) Upper 15.5%(1)

Solubility

Cold Water 18.1 g/l at 20 C(1) Hot Water Ethanol miscible

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid, red label Coast Guard Classification red label

Comments readily resinifies to a dimer when pure; usually stabilized with 7% water.

References (1) 1492

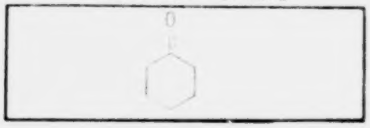
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Cyclohexanone (133)

IUC Name cyclohexanone

Common Names

Structural Formula



Molecular wt. 98.14 Melting Pt. -45.0 C(1) Boiling Pt. 155.6 C(1)

Density (Condensed) 0.9478 @ 20/4 C(1) Density (gas) 3.4(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 38.7 C(1) @ @

Flash Point 111 F(1) Autoignition Temp. 788 C(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.1% (1000 C)(1) Upper

Solubility

Cold water 3.6 wt.% at 20 C(1) Hot water Ethanol miscible(2)

Others miscible ethyl acetate, petroleum solvents, aromatic hydrocatbons.(2)

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments MCA warning label

References

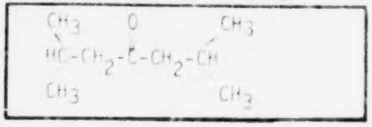
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Diisobutylketone (157)

IUC Name 2,6-dimethyl-4-heptanone

Common Names isovalerone

Structural Formula



$$\begin{array}{l}CH_3 \quad\quad\quad\quad O \quad\quad\quad\quad CH_3\\ HC-CH_2-C-CH_2-CH\\ CH_3 \quad\quad\quad\quad\quad\quad\quad\quad\quad CH_3\end{array}$$

Molecular wt. 142.2 Melting Pt. ______ Boiling Pt. 166 C(1)

Density (Condensed) 0.81(1) @ ______ Density (gas) 4.9(1) @ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ ______ ______ @ ______

Flash Point 104 F(1) Autoignition Temp. ______

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower 0.8% at 212 F(1) Upper 6.2% at 212 F(1)

Solubility

Cold Water ______ Hot Water ______ Ethanol ______

Others: ______

Acid, Base Properties ______

Highly Reactive with ______

Compatible with ______

Shipped in ______

ICC Classification ______ Coast Guard Classific

Comments MCA warning label

References (1) 0766

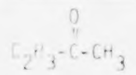
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethyl Methyl Ketone (193)

IUC Name 2-butanone

Common Names methyl ethyl ketone, MEK

Structural Formula



$C_2H_3\text{-}\overset{\overset{O}{\|}}{C}\text{-}CH_3$

Molecular wt. 72.10 Melting Pt. -85.9 C(1) Boiling Pt. 79.57 C(1)

Density (Condensed) 0.80615 @ 20/20 C(1) Density (gas) 2.41(1) @

Vapor Pressure (recommended 55 C and 20 C)

71.2 mm @ 20 C(1) @ @

Flash Point 22 F (T.O.C.)(1) Autoignition Temp. 960 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.8%(1) Upper 10%(1)

Solubility

Cold Water Hot Water Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid, red label Coast Guard Classification red label

Comments

References (1), 0766

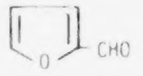
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Furfural (203)

ICC Name

Common Names 2-furancarbonal, 2-furaldehyde, fulale, fural

Structural Formula



Molecular wt. 96.1 Melting Pt. -36.5 C(1) Boiling Pt. 161.7 C(1)

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 140 F (C.C.)(1) Autoignition Temp. 600 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.1% at 125 C(1) Upper

Solubility

Cold Water soluble(2) Hot Water Ethanol very soluble(2)

Others: very soluble ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

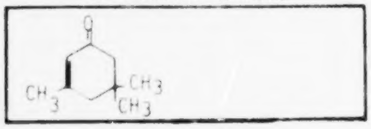
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Isophorone (226)

IUC Name 3,5,5-trimethyl-2-cyclohexenone

Common Names

Structural Formula



Molecular wt. 138.1 Melting Pt. Boiling Pt. 215.2 C(1)

Density (Condensed) 0.9229 @ Density (gas) 4.77(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 38.0 C(1) @ @

Flash Point 205 F (O.C.)(1) Autoignition Temp. 864 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 0.8%(1) Upper 3.8%(1)

Solubility

Cold water insoluble Hot water Ethanol soluble

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 5766

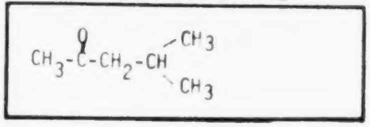
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Methyl Isobutyl Ketone (271)

IUC Name 2-methyl-2-pentanone

Common Names hexone, isopropylacetone

Structural Formula



$$CH_3-\overset{O}{\overset{\|}{C}}-CH_2-CH(CH_3)_2$$

Molecular wt. 100.2 Melting Pt. -80.3 F(1) Boiling Pt. 118 C(1)

Density (Condensed) 0.803(1) @ Density (gas) 3.45(1) @

Vapor Pressure (recommended 55 C and 20 C)

16 mm @ 20 C(1) @ @

Flash Point 73 F(1) Autoignition Temp. 858 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.3% at 122 F(1) Upper 8.0% at 212 F(1)

Solubility

Cold Water slightly Hot Water Ethanol soluble

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

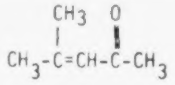
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Mesityl Oxide (259)

IUC Name 4-methyl-3-penten-2-one

Common Names

Structural Formula



$CH_3-\overset{\overset{CH_3}{|}}{C}=CH-\overset{\overset{O}{\|}}{C}-CH_3$

Molecular Wt. 98.14 Melting Pt. -59 C(1) Boiling Pt. 130.0 C(1)

Density (Condensed) 0.8539 @ 20/4 C(1) Density (gas) 3.38(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 26.0 C(1) @ @

Flash Point 90 F (C.C.) Autoignition Temp. 652 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water 3 wt.%(2) Hot Water Ethanol miscible(2)

Others: miscible most organic liquids.(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Paraformaldehyde (320)

IUC Name

Common Names trioxymethylene, paraform trioxane

Structural Formula

$(CH_2O)_xHOH$

Molecular wt. Melting Pt. 120-160 C(1) Boiling Pt. decomposed to formaldehyde

Density (Condensed) 1.39(1) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

1.45 mm @ 25 C(1) @ @

Flash Point 158 F(1) Autoignition Temp. 572 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water slowly soluble(2) Hot Water soluble(2) Ethanol insoluble(2)

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments MCA warning label.

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Propionaldehyde (355)

IUC Name propanal

Common Names propyl aldehyde

Structural Formula

$CH_3\text{-}CH_2\text{-}CHO$

Molecular Wt. 58.1 Melting Pt. -81 C(1) Boiling Pt. 48 C(1)

Density (Condensed) 0.807 @ 20/4 C(1) Density (gas) 2.0(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 15-19 F (O.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 3.7%(1) Upper 16.1%(1)

Solubility

Cold Water 20 vol.% at 20 C(2) Hot Water Ethanol miscible(2)

Others: miscible ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 1492

# PROFILE REPORT

# ALIPHATIC AND AROMATIC CARBONYL COMPOUNDS AND DERIVATIVES

Acetic Acid (2), Acetic Anhydride (3), Acetyl Chloride (9), Formaldehyde (201), Oleic Acid (316), Phthalic Anhydride (337), Sodium Formate (390), Sodium Oxalate (398)

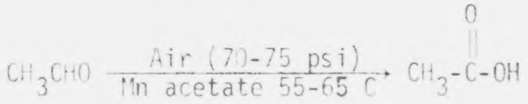
## 1. GENERAL

### Introduction

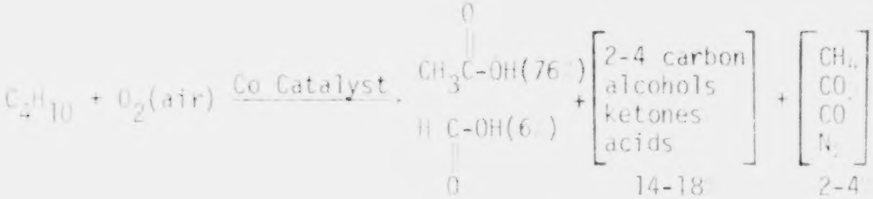
The aliphatic and aromatic carbonyl compounds and their derivatives treated in this report all have been selected as probable candidate waste stream constituents for industrial disposal. These materials are similar in that most are commodity chemicals with many common chemical characteristics. There are well-defined and safe methods of industrial handling and common methods of waste disposal.

### Manufacture and Use

Acetic acid is presently manufactured from acetyldehyde by catalytic oxidation in either batch, continuous batch or gas phase processes (Equation 1); by catalytic gas phase oxidation of butane (Equation 2); or by the destructive distillation of wood.[50]



$$CH_3CHO \xrightarrow[\text{Mn acetate 55-65 C}]{\text{Air (70-75 psi)}} CH_3\text{-}\overset{\overset{\displaystyle O}{\|}}{C}\text{-}OH \qquad (1)$$

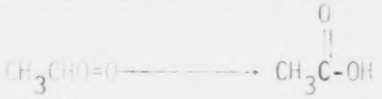


$$C_4H_{10} + O_2(\text{air}) \xrightarrow{\text{Co Catalyst}} \begin{matrix} CH_3\overset{\overset{O}{\|}}{C}\text{-}OH(76\%) \\ H\underset{\underset{O}{\|}}{C}\text{-}OH(6\%) \end{matrix} + \underset{14\text{-}18\%}{\begin{bmatrix}\text{2-4 carbon} \\ \text{alcohols} \\ \text{ketones} \\ \text{acids}\end{bmatrix}} + \underset{2\text{-}4\%}{\begin{bmatrix} CH_4 \\ CO_2 \\ CO \\ N_2 \end{bmatrix}} \quad (2)$$

Acetic acid is used to make cellulose acetate (via acetic anhydride) (47%), vinyl acetate (25%) and other acetates (16%). Miscellaneous uses account for 12 percent of the volume.[1506]

Acetic anhydride is manufactured by the reaction of acetyldehyde with acetic acid, which is made in situ by the catalytic oxidation of acetyldehyde (Equations 3,4) or by the reaction of acetic acid with ketene which is produced by cracking of acetic acid (Equations 5,6).

From acetyldehyde at 60 psi, 50 to 70 C and Co-Mn acetate catalyst:

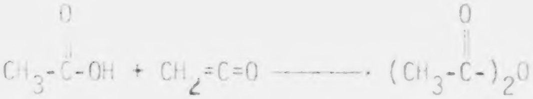


$$CH_3CHO{=}O \longrightarrow CH_3\overset{\overset{O}{\|}}{C}\text{-}OH \quad (3)$$

$$CH_3CHO + CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-}OH \longrightarrow (CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-})_2O \quad (4)$$

From acetic acid (ketene) at 700 to 800 C and 200 mm:

$$CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-}OH \longrightarrow CH_2{=}C{=}O \quad (5)$$



$$CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-}OH + CH_2{=}C{=}O \longrightarrow (CH_3\text{-}\overset{\overset{O}{\|}}{C}\text{-})_2O \quad (6)$$

The uses for acetic anhydride are the production of cellulose acetate (90%), vinyl acetate (5%), aspirin (1%) and all others (4%).[1506]

Acetyl chloride is made by treating sulfur dioxide and chlorine with sodium acetate followed by distillation. When used in situ as a catalyst, it is prepared by treating acetic anhydride with hydrogen chloride at 65 to 90 C.[1433]

$$2CH_3\text{-}\overset{O}{\overset{\|}{C}}\text{-}ONa + Cl_2 \longrightarrow 2\ CH_3\text{-}\overset{O}{\overset{\|}{C}}\text{-}Cl + Na_2SO_4$$

Acetyl chloride is used on a large scale as a catalyst in the chlorination of acetic acid, as an acetylating agent in organic synthesis and in the preparation of anhydrides of carboxylic acids.[1433]

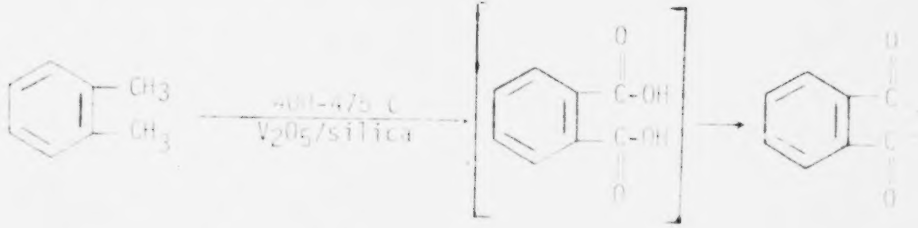
Formaldehyde is produced by the catalytic oxidation of methanol at 300 to 650 C using a silver-copper or iron-molybdenum-vanadium catalyst. Gaseous formaldehyde readily polymerizes and, for this reason, is sold only as aqueous solutions in which it is stable.[1433,1501]

$$CH_3OH + O_2(air) \longrightarrow CH_2O + H_2O$$

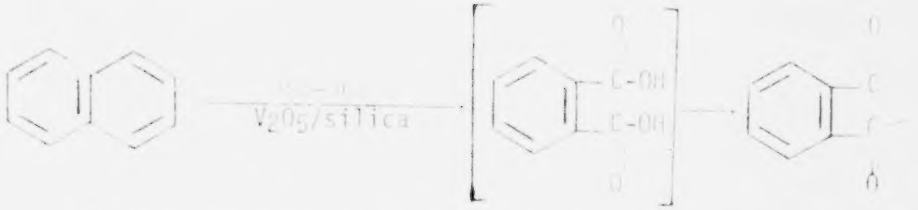
Formaldehyde is used to make resins (60 ), pentaerythritol (9 ), ethylene glycol (12 ),hexamethylenetetraamine (5 ) and miscellaneous items (14 ).

Oleic acid is made by the saponification of animal, corn, cottonseed and linseed oils and fats, followed by purification or fractionation into the various components of which oleic acid is one. Commercial "oleic" acid or red oil is a byproduct of the production and purification of stearic acid obtained from animal fats. Oleic acid is used in plasticizers (as the ester), in surface active agents (amine derivatives, esters, etc.), and in lubricants.[1433]

Phthalic anhydride is made by several processes which involve the catalytic ($V_2O_5$) gas phase air oxidation of either napthalene or o-xylene at 300 to 500 C to phthalic acid which then dehydrates to phthalic anhydride (Equations 9,10).[1501]



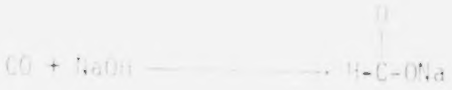
(9)



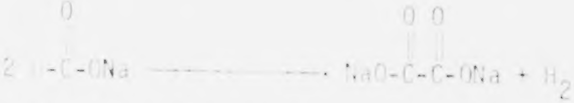
(10)

Phthalic anhydride is used to make diesters such as dioctyl phthalate which are used as plasticizers (48 ), in alkyd resins (30 ), in unsaturated polyester resins (14 ) and in the manufacture of dyes and chemical intermediates [illegible].[1506]

Sodium formate is an intermediate in the production of formic acid and sodium oxalate. The reaction of carbon monoxide with sodium hydroxide at [illegible] to [illegible] psi produces sodium formate (Equation 11). After the initial reaction, the excess carbon monoxide may be vented and the temperature raised to [illegible] to [illegible] to produce sodium oxalate (Equation 12).



$$\mathrm{CO + NaOH \longrightarrow H{-}\overset{\overset{\displaystyle O}{|}}{C}{-}ONa} \qquad (11)$$



$$\mathrm{2\ H{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}ONa \longrightarrow NaO{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}\overset{\overset{\displaystyle O}{\|}}{C}{-}ONa + H_2} \qquad (12)$$

The major use of sodium formate is to make formic acid which is used mainly for textile dyeing and finishing (50 ), chemical synthesis (25 ) and in the leather industry (15 ). Sodium oxalate is used to make oxalic acid which is utilized in metal and equipment cleaning (27 ), laundry, textile and leather industries (27 ), for chemicals (25 ) and other miscellaneous uses (21 ).[1506]

## Physical and Chemical Properties

The physical and chemical properties of the compounds discussed in this report are included in the attached worksheets.

## 2. TOXICOLOGY[0766,1433]

Acetyl Chloride, Acetic Anhydride and Acetic Acid. Acetic acid and its derivatives are irritants and corrosive on contact with tissue, particularly the eyes and upper respiratory tract. Systemic effects can be avoided by heeding the warnings of its presence - coughing and a burning sensation in the nose and throat. Ingestion causes a burning pain in the stomach followed by nausea and vomiting. Contact with the skin will cause reddening which may be followed by wrinkling, whitening and peeling. Repeated contact can cause dermatitis. Acetyl chloride will react instantly in the mouth causing corrosive damage and has its own toxic effect due to reaction with the -SH groups of protein molecules.

Phthalic Anhydride and Oleic Acid. These compounds present a very slight danger and the toxic effects are readily reversible.

Formaldehyde solution. Toxic effects are mainly those of irritation. If swallowed, it causes violent vomiting and diarrhea which can lead to collapse and even death. Repeated skin contact can cause dermatitis.

Sodium Formate and Sodium Oxalate. The toxic effects of these compounds resemble those of formic acid and oxalic acid respectively, except that acute local effects are much reduced due to lack of acidity. The presence of dusts or vapor causes irritation of the eyes and upper respiratory tract. Continued contact may cause ulcerations of the respiratory tract and skin lesions characterized by cracking and fissuring of the skin. The effect of ingestion of sodium formate is similar to that of acetic anhydride, but relatively mild compared to sodium oxalate. The systemic effects of sodium oxalate poisoning are mainly due to the removal of calcium from the blood by precipitation of calcium oxalate which clogs the renal tubes causing profound kidney disturbance.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) that have been established are:

| Substance | TLV<br>ppm | TLV<br>mg/M$^3$ | MAC<br>ppm |
|---|---|---|---|
| Acetic acid | 10 | 25 | - |
| Acetic anhydride | 5 | 20 | 12 |
| Acetyl chloride | - | - | - |
| Formaldehyde | 5 | 6 | 5 |
| Oleic acid | - | - | - |
| Phthalic anhydride | 2 | 12 | 2 |
| Sodium formate | 5 | 9[a] | - |
| Sodium oxalate | - | 1[a] | - |

a) as free acid.

## 3. OTHER HAZARDS

Acetyl chloride and acetic anhydride can react violently with water, alcohols, amines and other active hydrogen compounds unless the heat of reaction is adequately dissipated.[1433,1569]

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Storage and Transportation

With the exception of oleic acid and phthalic anhydride, these materials are all toxic to a certain extent by inhalation and are moderate to extensive skin, mucous membrane and respiratory tract irritants. Thus, these materials should be handled in a well-ventilated area and protective clothing and respirators are recommended where necessary. In cases of accidental contact, all contaminated clothing should be removed instantly and the skin washed thoroughly with soap and water. Showers and eye fountains must be available for serious accidents.

Storage of these materials should be in cool, dry, well-ventilated areas, away from acute fire hazards. Acetyl chloride, with its low boiling point should be protected from excessive heat and against sudden rise in temperature.

These materials are shipped under a variety of U.S. Department of Transportation, U.S. Coast Guard and IATA regulations. Most regulations relate to the flammability, corrosiveness and volatility of these compounds.[0766] Information on safe handling and use of these compounds can be found in the chemical data sheets published by the Manufacturing Chemists Association,[illegible] standard reference sources,[0766,1433,1492] or manufacturers' technical data sheets.[illegible]

## Use/Disposal

The chemicals in this group are used almost exclusively within the chemical process industries as chemical intermediates in the production of plastics, resins, plasticizers, surface agents and organic chemicals. These uses are characterized by a very high degree of utilization due to recycling of the unreacted materials, the main source of waste being scrubbing solutions used to remove trace amounts of reactants.[1506]

Both sodium formate (as the salt and free acid) and, to a much lesser extent, oxalic acid, are used in textile finishing and in leather tanning. Both industries generate large amounts of aqueous wastes with very high chemical and biological oxygen demands, of which only a small part is due to formic and oxalic acids. These wastes have been of some concern for a long time and presently most are treated by conventional activated sludge methods either on site or via contracts with local sewage treatment plants.[illegible]

Sodium oxalate and oxalic acid are used extensively for metal and equipment cleaning. In such applications, they are used in small amounts periodically or as necessary at widely scattered sites. Presently, they are discharged directly into the sewer with little or no treatment.

Recommended provisional limits for the compounds discussed in this report are listed below.

| Contaminant in Air | Provisional Limit ppm | mg/M$^3$ | Basis for Recommendation |
|---|---|---|---|
| Acetic Acid | .10 | .25 | .01 TLV |
| Acetic Anhydride | .05 | .20 | .01 TLV |
| Acetyl Chloride | - | .01 | Based on similar compounds |
| Oleic Acid | - | .25 | Based on similar compounds |
| Phthalic Anhydride | .02 | .12 | .01 TLV |
| Formaldehyde | .05 | .06 | .01 TLV |
| Sodium Formate[b] | - | .09 | .01 TLV |
| Sodium Oxalate[b] | - | .01 | .01 TLV |

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Acetic Acid | 1.25 | Stokinger and Woodward Method |
| Acetic Anhydride | 1.0[a] | Stokinger and Woodward Method |
| Acetyl Chloride | .05 | Based on similar compounds |
| Oleic Acid | 1.25 | Based on similar compounds |
| Phthalic Anhydride | .60 | Stokinger and Woodward Method |
| Formaldehyde | .15 | Stokinger and Woodward Method |
| Sodium Formate[b] | .45 | Stokinger and Woodward Method |
| Sodium Oxalate[b] | .05 | Stokinger and Woodward Method |

[a] Decomposes into acetic acid.

[b] As free acid.

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No.1 - Disposal of Acetyl Chloride, Acetic Anhydride and Phthalic Anhydride by Reaction with Water

Small amounts of acetyl chloride, acetic anhydride and phthalic anhydride can be destroyed by reaction with water. Acetyl chloride and acetic anhydride react vigorously with water to produce acetic acid while phthalic acid will react slowly in basic solution to produce a soluble phthalate salt. After conversion to the free acid or acid salt and suitable dilution, they may be treated according to Option No.2 before final discharge.

### Option No.2 - Treatment of Waste Water to Reduce Biological and Chemical Oxygen Demand

Aqueous solutions of the carbonyl compounds treated in this report are ideal candidates for chemical and biological degradation.[1543] These solutions may either be the result of dissolving waste material in water or of a process that produces aqueous waste streams. Depending on the quality and quantity of effluent generated at a given site, treatment can be carried out on site and/or by municipal waste treatment systems. Final discharge must meet water quality standards.

### Option No.3 - Incineration

With the exception of sodium formate and sodium oxalate, unusable bulk materials in this group can be disposed of by incineration. Conversion of sodium formate and oxalate into formic and oxalic acids would allow incineration of these materials.

### Option No.4 - Process Modification as a Method of Waste Reduction

The growing pressure on the chemical process industries to control wastes from their manufacturing sites has caused a reexamination of operating conditions and potential recovery value of wastes. In fact, process modifications in the production of formaldehyde and acetic acid have substantially reduced the amount of wastes that are produced.[0314] Continued application of this approach is an excellent method of "waste treatment."

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

The wastes generated by the industries that produce and use the aliphatic and aromatic carbonyl compounds discussed in this report can be treated locally by the common industrial and municipal techniques discussed in Section 5. Therefore, these compounds are not judged to be candidate waste stream constituents requiring National Disposal treatment.

## 7. REFERENCES

0314. Jones, H.R., Environmental control in the organic and petrochemical industries. Park Ridge, New Jersey, Noyes Data Corporation, 1971.

0766. Sax, N.J. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corp., 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. New York, Interscience Publishers, 1966. 899 p.

1492. The Merck index of chemicals and drugs. 7th ed. Boston, D.C. Heath and Company, 1956. 1112 p.

1501. Faith, W.L., D.B. Keyes, and R.L. Clark. Industrial chemicals. 3d ed. New York, John Wiley & Sons, Inc., 1965. 824 p.

1506. Oil, paint and drug reporter profiles. New York, Schnell Publishing Company, Inc. 1970.

1569. Manual of hazardous chemical reactions. Boston National Fire Protection Association, 1971. 308 p.

1570. Weast, R.C., ed. Handbook of chemistry and physics. 48th ed. Cleveland, Ohio, Chemical Rubber Company, 1969. 2,100 p.

2443. Formaldehyde chemical safety data sheet SD-1. Washington, Manufacturing Chemists Association, 1960. 14 p.

2444. Acetic anhydride chemical safety data sheet SD-15. Washington, Manufacturing Chemists Association, 1967. 16 p.

2445. Acetic acid chemical safety data sheet SD-41. Washington, Manufacturing Chemists Association, 1951. 15 p.

2446. Phthalic anhydride chemical safety data sheet SD-61. Washington, Manufacturing Chemists Association, 1956. 16 p.

2447. Technical data sheet for organic acids and anhydrides. New York, Union Carbide Chemicals Company, 1960. 48 p.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Acetic acid (2)

IUC Name methanoic acid

Common Names vinegar acid, methane carboxylic acid

Structural Formula

$CH_3$-$CO_2H$

Molecular wt. 60.05 Melting Pt. 16.7 C(1) Boiling Pt. 118 C(1)

Density (Condensed) 1.049 @ 25/25 C(1) Density (gas) 2.07(2) @

Vapor Pressure (recommended 55 C and 20 C)

11.4 mm @ 20 C(2) @ @

Flash Point [illegible](1) Autoignition Temp. 800 F(2)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 5.4(2) Upper 16.0% (2) at 212 F

Solubility

Cold water miscible Hot water miscible Ethanol miscible

Others: miscible glycerol, carbon tetrachloride; very slightly carbon disulfide

Acid, Base Properties $K_a$ = [illegible]

Highly Reactive with: oxidizing agents such as nitric acid, chromic acid or anhydride, hydrogen peroxide, [illegible], sodium peroxide and permanganates(3)

Compatible with:

Shipped in:

ICC Classification corrosive liquid, white label Coast Guard Classification combustible liquid

Comments

References (1) 1492
(2) 0766
(3) 1569

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Acetic anhydride (3)

IUC Name ethnoic anhydride

Common Names acetyl oxide, acetic oxide

Structural Formula

$(CH_3\text{-}CO)_2O$

Molecular wt. 102.09 Melting Pt. -73.1 C(1) Boiling Pt. 140 C(1)

Density (Condensed) 1.082 @ 20/4 C(1) Density (gas) 3.52(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 36 C(1) @ @

Flash Point 129 F(C.C.)(1) Autoignition Temp. 734 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.7%(1) Upper 10.1%(1)

Solubility

Cold water soluble decomposition(2) Hot Water Ethanol soluble decomposition(2)

Others: soluble chloroform(2)

Acid, Base Properties

Highly Reactive with oxidizing agents such as chromic acid, chromic anhydride, nitric acid, perchloric acid, peroxides, permanganates.(3)

Compatible with

Shipped in

~~DOT~~ IATA Classification corrosive liquid, white label Coast Guard Classification combustible liquid

Comments

References (1) 0766
(2) 1492
(3) 1563

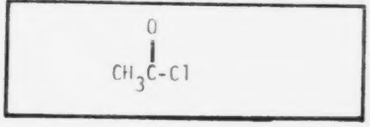
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Acetyl chloride (9)

IUC Name etahnoyl chloride

Common Names

Structural Formula



$CH_3C(=O)-Cl$

Molecular Wt. 78.50 Melting Pt. -112 C(1) Boiling Pt. 51-52 C(1)

Density (Condensed) 1.1051 @ 20/4 C(1) Density (gas) 2.70(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 40 F(C.C.)(1) Autoignition Temp. 734 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water decomposed(2) Hot Water decomposed(2) Ethanol decomposed(2)

Others: miscible benzene, chloroform, ether, glacial acitic acid, petroleum ether.(2)

Acid, Base Properties

Highly Reactive with water and alcohols to form acetic acid and acetates.(2) Reaction can be violent.(3)

Compatible with

Shipped in

IATA: Corrosive liquid, white label(1)

ICC Classification corrosive liquid, white label(1) Coast Guard Classification white label(1)

Comments

References (1) 0766

(2) 1492

(3) 1569

# HAZARDOUS WASTES PROPERTIES
# WORKSHEET

H. M. Name Formaldehyde, gas (201)

IUC Name methanol

Structural Formula

$CH_2O$

Common Names oxomethane, oxymethylene, methylene oxide, formic aldehyde, methyl aldehyde.

Molecular Wt. 30.03 Melting Pt. -92 C(1) Boiling Pt. -19.5 C(1)

Density (Condensed) 0.815 @ -20/4 C(1) Density (gas) 1.067(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp. 572 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water 55 %(2) Hot Water Ethanol soluble(2)

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments polymerizes very easily.

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name formaldehyde, aqueous solution* (201)

IUC Name methanol

Common Names see formaldehyde, gas

Structural Formula

$CH_2O$

Molecular wt. 30.03 Melting Pt. ______ Boiling Pt. -3 F(2)

Density (Condensed) 1.08 @ 25/25 C(1) Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ 806 F(2) ______ @ ______

Flash Point ______ Autoignition Temp.

185 F (37% methanol free); 122 F (15%, methanol free)(2)

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower 7.0% Upper 73.0%

Solubility

Cold water miscible(1) Hot water ______ Ethanol miscible(1)

Others: miscible, acetone(1)

Acid, Base Properties Acid, pH 2.8 - 4.0(1)

Highly Reactive As a reducing agent especially in the presence of base.

Compatible with ______

Shipped in ______

ICC Classification ______ Coast Guard Classification ______

Comments Shipped as 37% to 50% solution. The 37 wt.% solution with 10-15% methanol as a stabilizer is the most common.(1)

Polymerizes to form paraformaldehyde (trioxymethylene).

References (1) 1492
(2) 0766

*Data for 37% solution.

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Oleic acid (314)

IUC Name cis-9-octadecenoic acid

Common Names

Structural Formula

$C_{18}H_{34}O_2$

Molecular Wt. 282.45 Melting Pt. 14 C(2) Decomposition Pt. 80-100 C(1)

Density (Condensed) 0.895 @ 25/25 C Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 176.5 C(2) @ @

Flash Point 372 F(2). Autoignition Temp. 685 F(2)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water insoluble(1) Hot Water Ethanol soluble(1)

Others: soluble benzene, chloroform, ether, oils(1)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 1492
(2) 0766

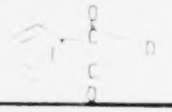
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Phthalic anhydride (337)

IUC Name

Common Names phthalandione

Structural Formula



Molecular wt. 148.11 Melting Pt. 131.2 C(1) Boiling Pt. 248.5 C(1)

Density (Condensed) 1.527 @ 4 C(1) Density (gas) 5.10(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 96.5 C(1) @ @

Flash Point 305 C(C.C.)(1) Autoignition Temp. 1083 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.7 Upper 10.4%(1)

Solubility

Cold Water 1% (Decomp.)(2) Hot Water soluble (decomp.)(2) Ethanol soluble(2)

Others: 1% carbon disulfide, sparingly in ether

Acid, Base Properties neutral

Highly Reactive with water and alcohol to form free acid or esters and half esters.

Compatible with

Shipped in
MCA warning label(1)

ICC Classification Coast Guard Classification

Comments A common air contaminant.

References (1) 0766
(2) 1492

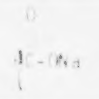
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Sodium formate (390)

IUC Name

Common Names

Structural Formula



$HC(=O)-ONa$

Molecular wt. 68.02 Melting Pt. 253 C[1] Boiling Pt.

Density (Condensed) 1.92 @ 20 C[1] Density (gas) - @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Slight fire hazard.

Solubility

Cold Water very soluble[2] Hot Water very soluble[2] Ethanol slightly[2]

Others soluble in glycerol

Acid, Base Properties neutral, pH 7 in aq solution- used as a buffer.[2]

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

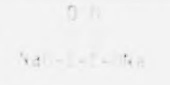
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Sodium oxalate (395)

IUC Name

Common Names

Structural Formula



$NaO-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-ONa$

Molecular Wt. [illegible] Melting Pt. Boiling Pt.

Density (condensed) [illegible] Density (gas)

Vapor Pressure (recommended 55 C and 20 C)

[illegible]

References (1) [illegible]

(2) [illegible]

# PROFILE REPORT

## Acetone Cyanohydrin (5), Acetonitrile (6), Acrylonitrile (11), Cyanoacetic Acid (130), Ethylene Cyanohydrin (173) and Toluene Diisocyanate (511)

## I. GENERAL

### Introduction[1433]

The nitriles are organic compounds containing a cyano radical, -CN, as the characteristic functional group. Toluene diisocyanate is distinguished by the presence of two isocyanate (-NCO) groups attached to the aromatic nucleus.

These materials have been grouped for discussion in this report because of their chemical and physical similarities and amenability to similar disposal procedures.

### Manufacture[1433]

Acetone Cyanohydrin. This hydroxynitrile is produced by a continuous process involving the reaction of acetone with hydrogen cyanide at 10 to 15 C, at a pH of 6.5 to 7.5. The reaction is a general method for the preparation of hydroxynitriles from aldehydes or ketones.

Acetonitrile. Acetonitrile is prepared by vapor phase ammonolysis of glacial acetic acid. The acid is vaporized, mixed with anhydrous ammonia, and the stream directed through a bed of silica gel or some other dehydration catalyst. The bed temperature may range from 150 to 500 C in this continuous process. The effluent gases contain acetonitrile, ammonia

Preceding page blank

and water and the product is recovered in 85 to 95 percent yields by azeotropic distillation.

Acrylonitrile. Acrylonitrile is currently produced from:(1) ethylene cyanohydrin; (2) acetylene and hydrogen cyanide; and (3) propylene and ammonia. In addition, several other possibly useful processes are described in the patent literature. The reaction of acetylene with hydrogen cyanide is utilized in the production of about two-thirds of the acrylonitrile produced in the United States.

Cyanoacetic Acid. The reaction of sodium cyanide with chloroacetic acid is employed in the commercial production of cyanoacetic acid. This method provides the acid in [illegible] percent yield.

Ethylene Cyanohydrin. Ethylene cyanohydrin is prepared by heating ethylene oxide and hydrogen cyanide together under controlled conditions.

Organic Isocyanates. Commercial manufacturing processes for aromatic isocyanates have the following general route: (1) a solution of an aromatic amine in an inert solvent such as xylene, monochlorobenzene, or o-dichlorobenzene is mixed with a solution of phosgene in the same solvent at a temperature of [illegible]; (2) the resulting slurry is then digested in one to three stages [illegible] hours at progressively increasing temperatures up to [illegible] with the introduction of additional phosgene; and (3) the final solution of reaction products is fractionated to recover hydrogen chloride, unreacted phosgene and solvent for recycling, a distillation residue which is incinerated, and the desired isocyanate.

## Uses

Acetone Cyanohydrin.[1433] The major use of acetone cyanohydrin is in the preparation of α-methacrylic acid and its esters, which are employed as monomers in the plastics industry. It is also used to prepare ethyl α-hydroxyisobutyrate, a pharmaceutical intermediate.

*Acetonitrile.*[1492] This nitrile is used as a starting material in the organic synthesis of many chemicals. It also is used to remove tars, phenol, and coloring matter from petroleum hydrocarbons as well as to extract fatty acids from animal and vegetable oils. It is a good non-aqueous solvent for inorganic salts and therefore is commonly used as a medium for analytical titrations.

*Acrylonitrile.*[1433] A wide variety of uses have been developed for acrylonitrile, particularly in synthetic fibers, plastics, modified natural fibers, polyelectrolytes and as a chemical intermediate.

*Cyanoacetic Acid.*[1492] Cyanoacetic acid is used in the synthesis of many intermediates and in the manufacture of barbital.

*Ethylene Cyanohydrin.*[1433] This material is manufactured on a large scale as an intermediate for acrylonitrile, acrylic acid, and acrylic acid ester.

*Toluene Diisocyanate.* Toluene diisocyanate is used extensively in the manufacture of polyurethan foams, elastomers and coatings for wire.

### Physical and Chemical Properties

The physical and chemical properties of these materials are included in the attached worksheets.

## 2. TOXICOLOGY

### Nitriles

The toxicity of nitriles ranges from high to moderate but they are only moderately hazardous as compared to hydrocyanic acid or to the isomeric organic isonitriles. Toxic quantities of nitriles may enter the body by ingestion, inhalation, and contact with the skin.[1433] Early symptoms of exposure to toxic concentrations of acrylonitrile include irritation of the eyes, nausea, and headache. The appearance of such symptoms necessitates immediate termination of the exposure.[2294] Nitriles act like cyanides with respect to human toxicity,[0766,1492] physiologically inhibiting tissue oxidation and causing death through asphyxia. The nitriles are, however, generally considered somewhat less toxic than hydrocyanic acid and other volatile inorganic cyanides as cyanogen because of their lower volatility.[0766]

Toluene diisocyanate can be hazardous in either its liquid or vapor form. On contact with the skin or eyes it produces irritation and if not removed immediately may cause burns. Inhalation of the vapors may be injurious to the lungs. The vapor is capable of producing difficult and labored breathing. Some individuals may develop a hypersensitivity to the vapors, and may then respond to very low concentrations.

## 3. OTHER HAZARDS

Caution must be observed when handling acetone cyanohydrin. This material readily decomposes to hydrogen cyanide and acetone. It should be kept in a slightly acidic environment,[0766] but strongly acid conditions should be avoided.[1569]

Acetonitrile will react with water, steam or acids to produce toxic and flammable vapors. It also can react vigorously with oxidizing materials.[0766]

Acrylonitrile ignites very readily. Its vapors, diffused in air over a considerable range of concentration are highly explosive. This material polymerizes violently in the presence of strong bases. Pure acrylonitrile is subject to self-polymerization with rapid pressure development in closed containers.[2294] Concentrated sulfuric acid mixtures must be kept well chilled to prevent a vigorous exothermic reaction occurring.[1569]

Ethylene cyanohydrin will react with water or steam to produce toxic and flammable vapors. It can also react vigorously with oxidizing materials.[0766]

Care should be taken to prevent toluene diisocyanate from coming into contact with basic compounds which might cause uncontrollable polymerization to take place. Large amounts of acidic materials may also cause rapid polymerization.[2295] Exposure of toluene diisocyanate to moisture leads to the formation of carbon dioxide and development of pressure in closed containers.[1437]

All of the subject materials are considered dangerous when heated to decomposition due to the emission of highly toxic fumes.[0766]

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Storage and Transportation

All precautions must be taken to guard against health and fire hazards wherever these materials are handled. If leaks or spills occur, only properly protected personnel should remain in the area. Leaking containers should be removed to the outdoors or to an isolated, well-ventilated area, and the contents transferred to other suitable containers.

The section on "Other Hazards" (Section 3) should be consulted in determining which of these materials may not be exposed to water during clean-up operations. Carbon dioxide, dry chemical or carbon tetrachloride are suitable materials for fighting fires.[0766]

A list of hazardous materials with packing and shipping instructions is found in the Code of Federal Regulations, Title 49, parts 100 to 199.[0278] Instructions are also included for articles whose proper shipping name is not shown in the commodity list and which must be classified as dangerous.

### Disposal/Reuse

Contaminated or degraded materials found to be unusable in a recycling process must be disposed of in a safe manner, defined in terms of the recommended provisional limits of those compounds in the environment. The recommended provisional limits are as follows:

| Contaminant in Air | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Acetone cyanohydrin | 0.45 $mg/M^3$ | Based on similar compounds |
| Acetonitrile | 0.4 ppm (0.7 $mg/M^3$) | 0.01 TLV |
| Acrylonitrile | 0.2 ppm (0.45 $mg/M^3$) | 0.01 TLV |
| Cyanoacetic acid | 0.01 $mg/M^3$ | Based on similar compounds |
| Ethylene cyanohydrin | 0.45 $mg/M^3$ | Based on similar compounds |
| Toluene diisocyanate | 0.0014 $mg/M^3$ | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Acetone cyanohydrin | 1.99 ppm (mg/l) | Based on similar compounds |
| Acetonitrile | 3.5 ppm (mg/l) | Stokinger & Woodward Method |
| Acrylonitrile | 1.99 ppm (mg/l) | Stokinger & Woodward Method |
| Cyanoacetic acid | 0.05 ppm (mg/l) | Based on similar compounds |
| Ethylene cyanohydrin | 1.99 ppm (mg/l) | Based on similar compounds |
| Toluene diisocyanate | 0.007 ppm (mg/l) | Stokinger & Woodward Method |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option 1. Recycling of Concentrated Waste

It would be advisable in all cases to first contact the manufactuers to determine if the material can be recycled. The applicability of this option depends on the type and extent of contamination or degradation the material has suffered.

### Option 2. Incineration of Concentrated and Dilute Organic Waste

In the event it becomes necessary to dispose of a significant quantity of organic waste and purification/recycling is impractical, incineration of the materials is the recommended method of disposal. The material must be incinerated under controlled conditions whereby oxides of nitrogen are removed from the effluent gas by scrubbers and/or thermal or catalytic devices.[1435]

### Option 3. Biological Treatment of Dilute Aqueous Waste

Nitriles are generally considered to be biodegradable.[0314] Some compounds can be degraded biologically only after extended periods of seed acclimation. The amenability of a particular compound to biological degradation is highly dependent on such environmental and growth factors as the nutrient requirements necessary for biological growth, and proper pH and temperature conditions for the microorganism. Conditions for the biological treatment of these individual compounds must be tailored to the particular waste stream in which they appear.

### Option 4. Activated Carbon Treatment of Dilute Aqueous Waste[0314]

Nitriles can be removed from waste water by treatment with activated carbon when they are present in low concentrations. This option is in essence a final "polishing" step to be used in conjunction with Option 3 to complete removal of resistant compounds from the stream before it is returned to the environment.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Most of the wastes generated by the industries that produce and use these materials can best be handled and treated at the site of the generation by the common industrial methods discussed in Section 5. Since adequate methods are available for disposal of these materials and they can be implemented by the manufacturers and users, they are not judged to be specific candidate waste stream constituents for National Disposal Sites, although they may well appear in mixed waste streams containing candidate constituents.

## 7. REFERENCES

0278. Code of Federal Regulations. Title 49 -- transportation, parts 100 to 199. (Revised as of January 1, 1972). Washington, U. S. Government Printing Office, 1972. 891 p.

0314. Jones, H. R. Environmental control in the organic and petrochemical industries. Park Ridge, New Jersey, Noyes Data Corporation 1971. 257 p.

0766. Sax, N. J. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corp., 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. 22v. and suppl. New York, Interscience Publishers, 1966. 899 p.

1435. John Zink Company. $NO_x$ destructor. Bulletin No. $NO_x$1071m, Tulsa, John Zink Company. 1 p.

1492. The Merck index of chemicals and drugs. 7th ed. Rahway, New Jersey, Merck Company, Inc. 1960. 1,634 p.

1569. Manual of hazardous chemical reactions. Boston National Fire Protection Association, 1971. 308 p.

1570. Weast, R. C., ed. Handbook of chemistry and physics. 48th ed. Cleveland, Chemical Rubber Company, 1969. 2,100 p.

1571. Schnell Publishing Company, Inc. 1971-72 OPD chemical buyers directory. 59th ed., New York, 1971. 1,584 p.

1655. Fieser, L. F. and M. Fieser. Organic chemistry. 3d ed. Boston, D. C. Heath and Company, 1956. 1,112 p.

2294. Manufacturing Chemists' Association, Inc. Chemical safety data sheet SD-31. Properties and essential information for safe handling and use of acrylonitrile. Revised 1964, Washington. 19 p.

2295. Manufacturing Chemists' Association, Inc. Chemical safety data sheet SD-73. Properties and essential information for safe handling and use of toluene diisocyanate. Revised 1971. Washington. 19 p.

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Acetone Cyanhydrin (5)

IUC Name 2-hydroxy-2-methylpropane nitrile$^{(1)}$

Common Names Acetone Cyanohydrin$^{(2)}$
α-hydroxy isobutyronitrile$^{(1)(2)}$ 2-methyllactonitrile$^{(4)}$
2-hydroxy-2-methyl propanoic acid nitrile$^{(3)}$

Structural Formula
$(CH_3)_2C(OH)CN$

Molecular Wt. 85.10$^{(4)}$ Melting Pt. -20 C$^{(4)}$ Boiling Pt. 82 C @ 23 mm$^{(4)}$
Density (Condensed) 0.932 @ 19 C$^{(4)}$ Density (gas) 2.93 @ air = 1

Vapor Pressure (recommended 55 C and 20 C)

____ @ ____ ____ @ ____ ____ @ ____

Flash Point ____ Autoignition Temp. 1270 F$^{(4)}$

Flammability Limits in Air (wt %) Lower ____ Upper ____
Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold Water Soluble$^{(2)}$ Hot Water Soluble$^{(2)}$ Ethanol Soluble$^{(2)}$
Others: Very soluble in ether$^{(3)}$ Insoluble in Pet. Ether$^{(3)}$
Very soluble in organic solvents$^{(3)}$

Acid, Base Properties ____

Highly Reactive with ____

Compatible with ____

Shipped in ____

ICC Classification Poison B$^{(4)}$ Coast Guard Classification Poison B$^{(4)}$

Comments ____

References (1) 1433 (4) 0766
(2) 1492
(3) 1570

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Acetonitrile (6)

[illegible] Name Ethanenitrile(1)

Structural Formula

$CH_3CN$

Common Names Cyanomethane(1) Methyl Cyanide(1)

[illegible] rabbits, [illegible] mg/kg

[illegible] oral rats, [illegible] g/kg

Molecular wt. [illegible](1) Melting Pt. -45.72 [illegible](1) Boiling Pt. [illegible](1)

Density (condensed) [illegible] Density (gas) [illegible](4)

Vapor Pressure (recommended [illegible]) [illegible]

Saturation Conc. [illegible]

[illegible]

[illegible] Classification [illegible] Coast Guard Classification [illegible]

Comments Max. practical working level [illegible] Source [illegible] Chemical Industries, Inc., [illegible] Eastman Chemical Products, Inc. Lonza Ltd., Vistron Corp.

References (1) 1570
(2) 1832
(3) 2571
(4) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

IUPAC Name Propenenitrile (1)

[illegible] Name

Common Names Propenenitrile(1), vinyl cyanide(1), [illegible]
cyanoethylene, carbacryl, ventox(1), [illegible]
[illegible]

Structural Formula

$CH_2=CHCN$

Molecular Wt. [illegible]

Melting Pt. [illegible]

Boiling Pt. 77.5 - 9 [illegible]

Density (condensed) [illegible] @ [illegible]

Density (gas) 1.83 @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible]

[illegible] @ 55 [illegible]

@

Flash Point [illegible]

Autoignition Temp. 898 F(4)

Flammability Limits in Air (wt %) Lower Upper

Explosive Mixtures with air Lower 3.05% Upper 17.0%

Solubility

Cold Water Soluble

Hot Water

Ethanol [illegible]

Others: soluble in ether

Acid, Base Properties

Highly Reactive with oxygen [illegible] the presence of peroxides(1); highly flammable, highly toxic, highly explosive [illegible]

Compatible with

Shipped in [illegible]

[illegible] Classification Flammable liquid

Coast Guard Classification Inflammable liquid

Comments Sources: American Cyanamid Co., [illegible] Products Co., E. I. duPont de Nemours & Co., B. F. Goodrich Chemical Co., International Chemical Corp., Monsanto Co.; Union Carbide Corp.; Vistron Corp.

References
(1) [illegible]
(2) [illegible]
(3) [illegible]
(4) [illegible]

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Cyanoacetic Acid (130)

IUC Name

Common Names Malonic Mononitrile

Structural Formula

$NCCH_2COOH$

Molecular wt. 85.06[1]    Melting Pt. 66 (1)    Boiling Pt. 160 d $b_{15}$ 108

Density (Condensed) @    Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@    @    @

Flash Point    Autoignition Temp.

Flammability Limits in Air (wt %)    Lower    Upper

Explosive Limits in Air (wt. %)    Lower    Upper

Solubility

Cold water Soluble    Hot water    Ethanol Soluble

Others: Soluble in ether, slightly soluble in benzene, chloroform.

Acid, Base Properties $pK_a^{25}$ 2.44 (4)

Highly Reactive with Decomposes at 160 into $CO_2$ and acetonitrile. Highly toxic (3)

Compatible with

Shipped in

ICC Classification    Coast Guard Classification

Comments Source (2): Kay-Fries Chemicals Inc.

References (1) 1492
(2) 1571
(3) 0766
(4) 1655

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethylene cyanohydrin (183)

IUC Name 3-hydroxy propane nitrile

Common Names Ethylene cyanohydrin(1)
Hydracrylonitrile(1)

Structural Formula

$HOCH_2CH_2CN$

Molecular wt. 71.08(1)  Melting Pt. -46 C(2)  Boiling Pt. 227-228 C(2)

Density (Condensed) 2.45(3) @ ______  Density (gas) 1.0404 @ 25 C(3)

Vapor Pressure (recommended 55 C and 20 C)

0.08 @ 25 C(3)  ______ @ ______  ______ @ ______

Flash Point [illegible] F(3)  Autoignition Temp. ______

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility

Cold water Infinitely soluble(1) Hot water ______ Ethanol Infinitely soluble

Others Sparcely soluble in ether(1) Insoluble in $CS_2$(1)

Acid, Base Properties ______

Highly Reactive with ______

Compatible with ______

Shipped in ______

ICC Classification ______ Coast Guard Classification ______

Comments ______

References (1) 1570
(2) 1433
(3) 3766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Toluene diisocyanate (411)

IUC Name

Common Names Toluene diisocyanate(1)
Tolylene diisocyanate, TDI

Structural Formula

$CH_3C_6H_3(NCO)_2$

Molecular wt. 174.16(2)
Freezing Pt. 21.8 C
Boiling Pt. 251 C

Density (Condensed) 1.22 @25/15.5 C(1)
Density (gas) 6.0 @
Air = 1

Vapor Pressure (recommended 55 C and 20 C)

0.01 mm @ 25 C
@
@

Flash Point 132 C(1) (tag open cup)
Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water
Hot water
Ethanol
Others

Acid, Base Properties Relatively noncorrosive at normal temperatures(1)

Highly Reactive with water with evolution of carbon dioxide(1)

Compatible with

Shipped in drums, tank trucks or tank cars.

ICC Classification
Coast Guard Classification

Comments Sources(1) - Allied Chem. Co.; BASF Wyandotte Corp., Conray Products, E. I. duPont de Nemours & Co. Inc (See Ref.)

References (1) 229
(2) 1492
(3) 1571

# PROFILE REPORT

## ALIPHATIC HYDROCARBONS

Acetylene (7), Butadiene (68), Butane (69), 1-Butene (71), Butylene (76), Cyclohexane (131), Dicyclopentadiene (148), Diisobutylene (156), Ethylene (181), n-Heptane (207), 1-Heptene (208), Hexane (211), Isopentane (225), Isoprene (227), Naphtha (crude) (284), n-Pentane (323), Propane (354), Propylene (360), Tetrapropylene (429), Tripropane (Norene)446), Turpentine (447) Ethane (493).

## AROMATIC HYDROCARBONS

Benzene (54), Creosote (coal tar)(123), Cumene (127), Dodecylbenzene (169), Ethylbenzene (179), Naphthalene (285), Styrene (412), Toluene (434), Xylene (457), Anthracene (466).

## 1. GENERAL

### Introduction

The hydrocarbons treated in this report have all been selected as probable candidate waste stream consituents for municipal disposal. These materials are similar in that most are commodity chemicals with relatively low toxicity, well defined and safe methods of industrial handling and common methods of disposal. The aliphatic and aromatic hydrocarbons are, therefore, discussed as a class in this report.

### Manufacture

The compounds treated in this report, with the exception of those discussed below, are all petroleum-based materials. The saturated hydrocarbons, naphtha, and small amounts of benzene and unsaturated aliphatics are isolated directly from petroleum by distillation. The remainder are classified as petrochemicals and are manufactured at sites within or in close proximity to petroleum refineries.[1655]

The alkenes such as butylene, styrene, propylene, etc., are usually made from the corresponding saturated material by dehydration at high temperature over chromia-alumina catalysts. The use of hexane or higher hydrocarbons results in the production of benzene, toluene, the xylenes, etc.[2480]

In the last 10 to 20 years, substantial advances in the area of catalytic cracking and refining of petroleum fractions has allowed the production of high volume items such as ethylene, benzene and toluene from a wide variety of materials.[1453,2480]

Dimers, trimers and tetramers are made by selective polymerization of such alkenes as propylene, butylene or cyclopentene. A wide range of catalysts and reaction conditions are employed to produce the required product.[2480]

Naphthalene, creosote and the anthracenes are produced from coal tar. Turpentine is made from the destructive distillation of the southern pine, Pinus palustris.[1452]

## Uses[1453,1452,1655]

The saturated aliphatic and aromatic hydrocarbons as well as turpentine are used in a wide variety of applications as fuels, solvents, reaction media and in hundreds of formulations of industrial and consumer items. The alkenes and alkene dimers and trimers are used either to produce polymers directly or to make other monomers.

Creosote is used to protect wood from insects, anthracene is used in the production of dyestuffs and naphthalene in the production of phthalic and anthranilic acids, dyestuffs, resins and in the manufacture of hydronaphthalenes.

More detailed descriptions of the various uses of the aliphatic and aromatic hydrocarbons can be found in standard reference sources.

## Physical and Chemical Properties

The physical and chemical properties of the compounds discussed in this report are included in the attached worksheets.

## 2. TOXICOLOGY

### Aliphatic Hydrocarbons[0766,1492]

The aliphatic hydrocarbons are classified as simple asphyxiant gases having no specific toxic effect, but acting by excluding oxygen from the lungs. Since a 33 percent concentration is necessary before appreciable symptoms develop, they become severe fire and explosion hazards long before danger from lack of oxygen develops. Hydrocarbons with boiling points below room temperature can cause frostbite when spilled on the skin by evaporative cooling. Repeated contact with the skin can cause irritation by removal of the skin oils. Turpentine, a natural product, is a mild allergen and can cause serious kidney irritation.[1492]

### Aromatic Hydrocarbons

The toxicity of the mononuclear aromatic hydrocarbons decreases with increasing alkyl substitution in the ring. Thus benzene is more toxic than toluene, which in turn is more toxic than xylene. Poisoning can occur by inhalation, ingestion or skin absorption.

Locally, these compounds have a relatively strong, irritating effect producing erythema, burning, and in severe cases edema. Exposure to high vapor concentration is similar to other anaesthetic gases.

Chronic exposure is dangerous due to its toxic action on the blood-forming tissue. There are no specific set of blood symptoms in chronic poisoning and individual susceptibility varies widely.

Naphthalene is relatively non-toxic, but poisoning will occur by ingestion of large doses, inhalation or skin absorption causing nausea, vomiting, headache, hemalytic anemia, hepatic necrosis, convulsions, and coma. Anthracene is non-toxic, but it is thought that industrial material is carcinogenic because of impurities.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) that have been established are:

| Aliphatic Hydrocarbons: | TLV |  | MAC |
|---|---|---|---|
|  | ppm | mg/M$^3$ | ppm |
| Acetylene | - | - | - |
| Butadiene | 1000 | 2200 | - |
| Butane | 500 | 1200 | - |
| 1-Butene | - | - | - |
| Butylene | - | - | - |
| Cyclohexane | 300 | 1050 | 400 |
| Dicyclopentadiene | - | - | - |
| Diisobutylene | - | - | - |
| Ethane | - | - | - |
| Ethylene | - | - | - |
| n-Heptane | 500 | 2000 | 500 |
| 1-Heptene | - | - | - |
| Hexane | 500 | 1800 | 500 |
| Isopentane | - | - | - |
| Isoprene | - | - | - |
| Naphtha | 100 | 400 | - |
| Pentane | 500 | 1500 | 1000 |
| Propane | - | - | - |
| Propylene |  | - | - |
| Tetrapropylene | - | - | - |
| Tripropylene | - | - | - |
| Turpentine | 100 | 560 | 100 |
| Aromatic Hydrocarbons |  |  |  |
| Anthracene | - | - | - |
| Benzene | 25 | 80 | 25 |
| Creosote | 5 | 22 | - |
| Cumene | 50 | 245 | 100 |
| Dodecylbenzene | - | - | - |
| Ethylbenzene | 100 | 435 | 100 |
| Naphthalene | 10 | 50 | 10 |
| Styrene | 100 | 420 | 100 |
| Toluene | 100 | 375 | 200 |
| Xylene | 100 | 435 | 200 |

## 3. OTHER HAZARDS

No hazards other than flammability are present during the handling and use of these compounds with the exception of acetylene. Dry salts of acetylene are explosive and very prone to spontaneous detonation.[1569,1655]

## 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

### Handling, Storage, and Transportation[0766,1433]

Most of the chemicals in this group are rated as hazardous flammable chemicals because they have flash points below 100 C. In addition, many form explosive mixtures with air at concentrations as low as 1 percent. The danger is further complicated by the fact that very pure material has very little odor.

Care must be exercised in handling, storage and transportation to prevent container leakage. Whenever possible these materials should be kept in cool, well-ventilated areas, away from acute fire hazards. Industrial areas where these hydrocarbons are used should be equipped with spark-proof electrical apparatus. Materials with low boiling points should be protected from excessive heat and against sudden rise in temperature.

These materials are shipped under a variety of U.S. Department of Transportation, U. S. Coast Guard, and International Air Transport Association (IATA) regulations. Most regulations relate to the flammability and volatility of these compounds. Information on safe handling and use of these compounds can be found in the Chemical Data Sheets published by the Manufacturing Chemists Association, standard reference sources, or manufacturers' Technical Data Sheets.

### Disposal/Reuse

Petrochemical plants that use the hydrocarbons listed in this report recycle any unused or unreacted material. Hydrocarbons that are used as reaction media or solvents in commercial processes are also recycled indefinitely. The main sources of hydrocarbon wastes are dilute aqueous solutions that result from various washing procedures during manufacture and use, and hydrocarbon sludges containing varying amounts of the hazardous material in question. Presently the aqueous wastes are discharged into the sewer after skimming and primary treatment to reduce hydrocarbon content.

In some parts of the country, discharge directly into rivers and streams is still practiced. The sludges are also landfilled.[0590,0604] Large petrochemical plants incinerate a certain amount of liquid waste.[2480]

A small but significant amount of hydrocarbon wastes are generated in chemical laboratories, small manufacturing plants and various businesses that use them as solvents, cleaners and reaction media but do not have facilities for reclaiming spent solvents. Presently much of this material is picked up by scavengers who dispose of it by reclaiming, landfill, ocean burial, open burning or any other method that seems appropriate.[0596,0604]

Recommended provisional limits for the subject compounds are listed below.

| Constituent in Air | Provisional Limits | | Basis for Recommendation |
|---|---|---|---|
| Aliphatic Hydrocarbons | ppm | mg/M$^3$ | |
| Acetylene | - | 22 | Based on similar compounds |
| Butadiene | 10 | 22 | 0.01 TLV |
| Butane | 5 | 12 | 0.01 TLV |
| 1-Butene | 10 | 22 | Based on similar compounds |
| Butylene | 10 | 22 | Based on similar compounds |
| Cyclohexane | 3 | 10.5 | 0.01 TLV |
| Dicyclopentadiene | - | 15 | Based on similar compounds |
| Diisobutylene | - | 10 | Based on similar compounds |
| Ethane | - | 9 | Based on similar compounds |
| Ethylene | - | 22 | Based on similar compounds |
| n-Heptane | 5 | 20 | 0.01 TLV |
| 1-Heptene | - | 22 | Based on similar compounds |
| Hexane | 5 | 18 | 0.01 TLV |
| Isopentane | - | 15 | Based on similar compounds |
| Isoprene | - | 22 | Based on similar compounds |
| Naphtha | 1 | 4 | 0.01 TLV |
| Pentane | 5 | 15 | 0.01 TLV |
| Propane | - | 50 | Based on similar compounds |
| Propylene | - | 22 | Based on similar compounds |
| Tetrapropylene | - | 10 | Based on similar compounds |
| Tripropane | - | 10 | Based on similar compounds |
| Turpentine | 1.0 | 5.6 | 0.01 TLV |
| Aromatic Hydrocarbons | | | |
| Anthracene | 0.1 | 0.5 | Based on similar compounds |
| Benzene | 0.25 | 0.80 | 0.01 TLV |
| Creosote | 0.05 | 0.22 | Based on similar compounds |
| Cumene | 0.5 | 2.45 | 0.01 TLV |
| Dodecylbenzene | - | 3.75 | Based on similar compounds |
| Ethylbenzene | 1.0 | 4.35 | 0.01 TLV |

| Aromatic Hydrocarbons | Provisional Limits | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M$^3$ | |
| Naphthalene | 0.1 | 0.5 | 0.01 TLV |
| Styrene | 1.0 | 4.2 | 0.01 TLV |
| Toluene | 1.0 | 3.75 | 0.01 TLV |
| Xylene | 1.0 | 4.35 | 0.01 TLV |

| Constituent in Water and Soil | Provisional Limits ppm(mg/l) | Basis for Recommendation |
|---|---|---|
| Aliphatic Hydrocarbons | | |
| Acetylene | 110 | Based on similar compounds |
| Butadiene | 110 | Stokinger & Woodward Method |
| Butane | 60 | Stokinger & Woodward Method |
| 1-Butene | 110 | Based on similar compounds |
| Butylene | 110 | Based on similar compounds |
| Cyclohexane | 52.5 | Stokinger & Woodward Method |
| Dicyclopentadiene | 75 | Based on similar compounds |
| Diisobutylene | 50 | Based on similar compounds |
| Ethane | 45 | Based on similar compounds |
| Ethylene | 110 | Based on similar compounds |
| n-Heptane | 100 | Stokinger & Woodward Method |
| 1-Heptene | 110 | Based on similar compounds |
| Hexane | 90 | Stokinger & Woodward Method |
| Isopentane | 75 | Based on similar compounds |
| Isoprene | 110 | Based on similar compounds |
| Naphtha | 20 | Stokinger & Woodward Method |
| Pentane | 75 | Stokinger & Woodward Method |
| Propane | 50 | Based on similar compounds |
| Propylene | 110 | Based on similar compounds |
| Tetrapropylene | 50 | Based on similar compounds |
| Tripropane | 50 | Based on similar compounds |
| Turpentine | 28 | Stokinger & Woodward Method |
| Aromatic Hydrocarbons | | |
| Anthracene | 2.5 | Based on similar compounds |
| Benzene | 3.5 | Stokinger & Woodward Method |
| Creosote | .001 | Based on similar compounds |
| Cumene | 12.25 | Stokinger & Woodward Method |
| Dodecylbenzene | 18.75 | Based on similar compounds |
| Ethylbenzene | 21.75 | Stokinger & Woodward Method |
| Naphthalene | 2.5 | Stokinger & Woodward Method |
| Styrene | 21 | Stokinger & Woodward Method |
| Toluene | 18.75 | Stokinger & Woodward Method |
| Xylene | 4.35 | Stokinger & Woodward Method |

# 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

## Option No.1 - Recycling

The industries that use hydrocarbons as intermediates, solvents or reaction media recycle as much material as possible. A small amount of contaminated solvents from small users is reprocessed for downgraded uses. This should be considered the method of choice whenever possible.

## Option No.2 - Discharge of Dilute Aqueous Solutions into the Municipal or Industrial Sewer After Preliminary Treatment

Hydrocarbons show only slight solubility in water and the amount of dissolved or occluded material can be reduced even further by treatment appropriate to a given compound. In general, hydrocarbons show high resistance to biological degradation, but with the exception of some of the aromatics, they also have a very low toxicity to man, animals, fish and plants. Fortunately, the more toxic aromatics are less persistent than the aliphatics. In spite of the drawbacks, discharge into the municipal or industrial sewer system followed by secondary treatment under controlled conditions is considered as a valid method of disposal. Discharge directly into a stream or river is not acceptable.

## Option No.3 - Incineration

Unreclaimable solvents, solvent mixtures or sludges containing hydrocarbons can be disposed of by incineration. Although not in wide use at present, this is an excellent method because hydrocarbons are easily combusted to carbon dioxide and water. Incineration,being easy and safe, can be performed on site, by scavengers, or at a municipal incineration site.

## Option No.4 - Landfill of Residue, Sludges and Hydrocarbon Mixtures Obtained During Manufacture and Use

Presently hydrocarbon residues, sludges and in some areas hydrocarbon mixtures are landfilled, often at local municipal landfill sites. Since incineration is such an attractive alternative, and because landfill represents a long-term threat to underground water supplies, this option must be considered much less acceptable than Option No.3, incineration.

Option No.5 - Uncontrolled Disposal by Local Scavengers

Many small and some larger companies contract with local scavengers who then dispose of the materials by methods such as landfill, desert burial, open incineration at remote sites, and ocean burial. These scavengers offer high potential for resources recovery since they could be capable of concentrating wastes at a few sites where they could be treated by sensible means such as Option No. 1 (recycling) or Option No. 3 (incineration).

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

All of the wastes generated by the industries that produce and use these materials can be handled safely and easily locally by common industrial techniques. Dilute aqueous wastes can also be handled locally as discussed in Section 5. Therefore, the compounds treated in this report should be considered candidates for industrial or municipal disposal. Incineration at the National Disposal Site should be necessary only when the waste streams contain, in addition to one or more of the materials cited in this report, other constituents which cause the waste stream to become a candidate for National Disposal Sites.

# 7. REFERENCES

0973. Personal communication. R. Mahaffey, Napco Company to W.T. Kendrick, TRW Systems, February 11, 1972.

0974. Personal communication. R. Mahaffey, Napco Company to W.T. Kendrick, TRW Systems, February 15, 1972.

0766. Sax, N.I., Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. 22 v. New York, Interscience Publishers, 1963.

1570. Merck index of chemicals and drugs. 7th ed. Rahway, New Jersey, Merck Company, Inc., 1960. 1,634 p.

[illegible] Manual of hazardous chemical reactions. Boston, National Fire Protection Association, 1971. 308 p.

[illegible] Fieser, L.F., and M. Fieser. Organic chemistry. 3d ed. Boston, D.C. Heath and Company, 1956. p.145-160, 644-665.

2440. Personal communication. [illegible], TRW Systems to R.S. Ottinger, TRW Systems, October 20, 1972

2441. Thomas, C.L., Catalytic processes and proven catalysts. New York Academic Press, 1970. 283 p.

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Acetylene (7)

IUC Name ethyne

Common Names

Structural Formula

HC≡CH

Molecular wt. 26.04 Melting Pt. -81.8 C(1) Boiling Pt. -86.0 C(1)

Density (Condensed) @ Density (gas) 1.173 g/liter @ 0 C 760mm(1)

Vapor Pressure (recommended 55 C and 20 C)

40 atm @ 16.8 F(1) @ @

Flash Point 0 F (C.C.)(1) Autoignition Temp. 571 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.5%(1) Upper 80%(1)

Solubility

Cold Water slightly soluble(2) Hot Water Ethanol

Others: ether,(2) benzene,(2) acetone(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable gas, red gas label(1) Coast Guard Classification red gas label(1)

Comments sublimes at -86.0 C(1); forms explosive compounds with copper and silver.(1)

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Benzene (54)

IUC Name benzene

Common Names benzol, coal naphtha

Structural Formula

Molecular wt. 78.11 Melting Pt. 5.51 C[1] Boiling Pt. 80.093 C[1]

Density (Condensed) 0.8794 @ 20 C[1] Density (gas) 2.77[1] @

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ 26.1 C[1] @ @

Flash Point 12 F (C.C.)[1] Autoignition Temp 1044 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.3%[1] Upper 7.1%[1]

Solubility

Cold water insoluble[2] Hot water Ethanol miscible[2]

Others chloroform,[2] ether,[2] acetone[2]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label[1] Coast Guard Classification red label[1]

Comments

References (1) 1766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name [illegible] (68)

IUC Name [illegible]

Common Names

Structural Formula

[illegible]

Molecular wt. [illegible] Melting Pt. [illegible] (1) Boiling Pt [illegible] (1)

Density (condensed) [illegible] @ [illegible] (1) Density (gas) [illegible] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible] (1) @ @

Flash Point [illegible] F (1) Autoignition Temp. 804 F (1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.0% (1) Upper 11.5% (1)

Solubility

Cold water Hot water Ethanol soluble (2)

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Red Label (1) Coast Guard Classification

Comments

References (1) 766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name Butane (69)

IUC Name n-butane

Common Names

Structural Formula

$CH_3(CH_2)_2CH_3$

Molecular wt [illegible] Melting Pt. -138.3 C[1] Boiling Pt. 0.5[1]

Density (Condensed) [illegible] @ Density (gas) 2.046 -

Vapor Pressure (recommended 55 C and 20 C)

[illegible] atm @ [illegible] @ @

Flash Point -76 F (CC)[1] Autoignition Temp. 761 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.9[1] Upper 8.5[1]

Solubility

Cold water insoluble[2] Hot water Ethanol soluble[2]

Others ether,[2] chloroform[2]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red gas label[1] Coast Guard Classification red gas label[1]

Comments

References (1) 5766
(2) 449

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name 1-Butene (71)

IUC Name 1-butene

Common Names

Structural Formula

$CH_3CH_2CH=CH_2$

Molecular wt. 56.10    Melting Pt. -185.3 C(1)    Boiling Pt. -6.3 C(1)

Density (Condensed) 0.595 @ 20/4 C(1)    Density (gas) 1.93(1) @

Vapor Pressure (recommended 55 C and 20 C)

3480 mm @ 21 C(1)    @    @

Flash Point -112 F(1)    Autoignition Temp. 723 F(1)

Flammability Limits in Air (wt %)    Lower    Upper

Explosive Limits in Air (wt. %)    Lower 1.7%(1)    Upper 9.0%(1)

Solubility

Cold water    Hot water    Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification    Coast Guard Classification

Comments IATA - Flammable, red gas label.(1)

References (1) 0766

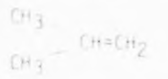
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butylenes (76)

IUC Name 2-methylpropene

Common Names Isobutene

Structural Formula



$$(CH_3)_2C{=}CH_2$$

Molecular wt. 56.1

Melting Pt. -140.3 C(1)

Boiling Pt. -6.9 C(1)

Density (Condensed) 0.600(1) @

Density (gas) 1.94(1) @

Vapor Pressure (recommended 25 C and 20 C)

3290 mm @ 40.5 C(1) @ @

Flash Point -20 F(1)

Autoignition Temp. 869 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower 1.8%(1) Upper 8.8%(1)

Solubility

Cold water Hot water Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 766

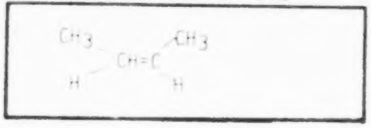
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butylenes (76)

IUC Name cis-2-butene

Common Names

Structural Formula



Molecular wt. 56.1 Melting Pt. -139 C(1) Boiling Pt. 1 C(1)

Density (Condensed) 0.627 @ 15.5/15.5 C(1) Density (gas) 1.9(1) @

Vapor Pressure (recommended 55 C and 20 C)

1410 mm @ 21 C(1) @ @

Flash Point 20 F(1) Autoignition Temp. 615 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.7%(1) Upper 9.0%(1)

Solubility

Cold Water Hot water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

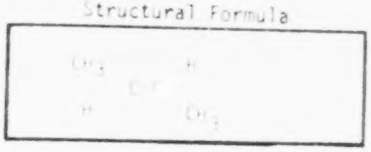
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butylenes (76)

IUC Name trans-2-butene

Common Names

Structural Formula



Molecular wt. 56.1 Melting Pt. -105.6 C[1] Boiling Pt. 2.5 C[1]

Density (condensed) [illegible][1] Density (gas) 1.95[1] @

Vapor Pressure (recommended 55 C and 20 C)

1592 mm @ 20 C[1] @ @

Flash Point 20 F[1] Autoignition Temp. 615 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.8%[1] Upper 9.7%[1]

Solubility

Cold water Hot Water Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Creosote, Coal Tar (123)

IUC Name Creosote oil

Common Names

Structural Formula
None

Molecular wt. Melting Pt. Boiling Pt. 200-250 C[1]

Density (Condensed) [illegible] [1] @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 165 F (C.C.)[1] Autoignition Temp. 637 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water insoluble[2] Hot Water Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification Combustible[1]

Comments Mixture of phenols from coal tar.[1]

References (1) 0766
(2) 1492

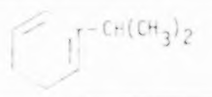
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Cumene (127)

IUC Name isopropyl benzene

Common Names Cumol, 2-phenylpropane

Structural Formula



Molecular wt. 120.19 Melting Pt. -96.0 C(1) Boiling Pt. 152 C(1)

Density (Condensed) 0.864 @ 20/4 C Density (gas) 4.1 @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 38.3 C(1) @ @

Flash Point 111 F(1) Autoignition Temp. 795 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 0.9%(1) Upper 6.5%(1)

Solubility

Cold water insoluble(2) Hot water Ethanol soluble(2)

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 1492

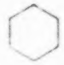
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Cyclohexane (131)

IUC Name cyclohexane

Common Names hexamethylene

Structural Formula



Molecular wt. 84.16 Melting Pt. 6.5 C(1) Boiling Pt. 80.7 C(1)

Density (Condensed) 0.7791 @ 20/4 C(1) Density (gas) 2.90 @

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ 60.8 C(1) @ @

Flash Point -4 F(1) Autoignition Temp. 500 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.3(1) Upper 8.4(1)

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Dicyclopentadiene (148)

IUC Name α-dicyclopentadiene

Common Names

Structural Formula

$C_{10}H_{12}$

Molecular Wt. 132.2 Melting Pt. 32.9 C(1) Boiling Pt. 166.6 C(1)

Density (Condensed) 0.976 @ 35 C(1) Density (gas) 4.55(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 47.6 C(1) @ @

Flash Point 90 F (O.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Diisobutylene (156)

IUC Name

Common Names

Structural Formula

$C_8H_{16}$

Molecular wt. 112.2 Melting Pt. ~ 101 C[1] Boiling Pt. 102 C[1]

Density (Condensed) 0.7227 @ 15.6 C[1] Density (gas) 3.97 @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 20 F (C.C.)[1] Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Hot water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

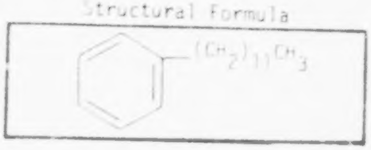
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Dodecylbenzene (169)

IUC Name dodecylbenzene

Common Name

Structural Formula



Molecular wt. 246.4 Melting Pt. Boiling Pt. 290-410 C(1)

Density (Condensed) @ Density (gas) 8.47 @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 285 F(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower Upper

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

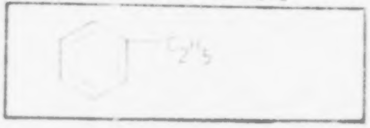
References (1) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethylbenzene (179)

IUC Name ethylbenzene

Structural Formula



Common Names phenylethane, ethylbenzol

Molecular wt. 106.16 (1) Melting Pt. -94.9 C(1) Boiling Pt. 136.2 C(1)

Density (condensed) 0.8669 @ 20/4 C(1) Density (gas) 3.66 @

Vapor Pressure (recommended 55 C and 20 C)

7 mm @ 20 C(1) @ @

Flash Point 59 F(1) Autoignition Temp. 810 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification Combustible(1)

Comments IATA - Flammable, red label.(1)

References (1) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name [illegible] (181)

IUC Name: Ethane

Common Names: [illegible]

Structural Formula

[illegible]

Molecular Wt: [illegible]  Melting Pt: [illegible]  Boiling Pt: [illegible]

Specific Gravity (Density): [illegible]  Density (gas): [illegible]

Vapor Pressure (Temperature °C and °F): [illegible]

Flash Point: [illegible]  Autoignition Temp: [illegible]

Flammability Limits in Air (wt %)  Lower [illegible]  Upper [illegible]

Explosive Limits in Air (wt %)  Lower [illegible][1]  Upper [illegible][1]

Solubility

Cold Water: [illegible]  Hot Water: [illegible]  Ethanol: slightly soluble[1]

Others: [illegible]

Acid, Base Properties:

Highly Reactive with:

Compatible with:

Shipped in:

ICC Classification: flammable, red label  Coast Guard Classification: red label[1]

Comments:

References: (1) [illegible]
(2) [illegible]

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name n-heptane (207)

[illegible] Name n-heptane

Common Names

Structural Formula

$CH_3(CH_2)_5CH_3$

Molecular Wt. [illegible]

Melting Pt. -90.5 C$^{(1)}$

Boiling Pt. 98.52 C$^{(1)}$

Density (Condensed) .684 @ 20/4 C$^{(1)}$

Density (gas) 3.45 @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ 22.3 C$^{(1)}$ @ @

Flash Point 25 F (-4 C)$^{(1)}$

Autoignition Temp. 433 C

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.2%$^{(1)}$ Upper 6.7%$^{(1)}$

Solubility

Cold water insoluble$^{(2)}$

Hot water

Ethanol soluble$^{(2)}$

Others: chloroform, ether$^{(2)}$

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification flammable, red label$^{(1)}$

Coast Guard Classification red label$^{(1)}$

Comments

References (1) 0766
(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name 1-heptene (208)

IUC Name 1-heptene

Common Names 1-heptylene

Structural Formula

$CH_2=CH(CH_2)_4CH_3$

Molecular wt. 98.2 Melting Pt. -10 C(1) Boiling Pt. 93.6 C(1)

Density (Condensed) 0.6969 @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name n-hexane (211)

IUC Name n-hexane

Common Names

Structural Formula

$CH_3(CH_2)_4CH_3$

Molecular wt. 86.17 Melting Pt. -95.6 C[(1)] Boiling Pt. 68.7 C[(1)]

Density (condensed) 0.6603 @ 20/4 C[(1)] Density (gas) 2.97 @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 15.8 C[(1)] @ @

Flash Point -7 F[(1)] Autoignition Temp. 500 F[(1)]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.2%[(1)] Upper 7.5%[(1)]

Solubility

Cold water insoluble[(2)] Hot water Ethanol miscible[(2)]

Others: chloroform, ether[(2)]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label[(1)] Coast Guard Classification red label[(1)]

Comments

References (1) 0766

(2) 1492

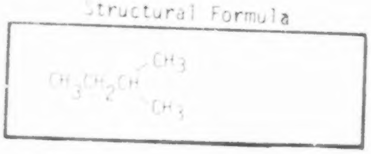
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Isopentane (225)

IUC Name 2-methylbutane

Common Names

Structural Formula



$CH_3CH_2CH(CH_3)CH_3$

Molecular wt. 72.15 Melting Pt. -160.5 C(1) Boiling Pt. 27.8 C(1)

Density (Condensed) [illegible] @ [illegible] 4(1) Density (gas) 2.48 @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible] @

Flash Point -70 F (-57 C)(1) Autoignition Temp. 788 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower 1.4(1) Upper 7.6%(1)

Solubility

Cold water Hot water Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 6766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Propane (254)

IUC Name propane

Common Names

Structural Formula

$CH_3CH_2CH_3$

Molecular wt. 44.09 Melting Pt. -187.1 C(1) Boiling Pt. -42.1 C(1)

Density (Condensed) 0.5852 @-44.5/4 C(1) Density (gas) 1.56 @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 156 F(1) Autoignition Temp. 874 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.3%(1) Upper 9.5%(1)

Solubility

Cold Water Hot Water Ethanol soluble(2)

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 1492

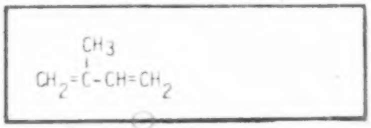
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Isoprene (227)

IUC Name 2-methyl-1,3-butadiene

Common Names

Structural Formula



$$CH_2=\overset{CH_3}{\overset{|}{C}}-CH=CH_2$$

Molecular wt. 68.11 Melting Pt. -146.7 C(1) Boiling Pt. 34 C(1)

Density (Condensed) 0.6806 @ 20/4 C(1) Density (gas) 2.35 @

Vapor Pressure (recommended 5 C and 20 C)

400 mm @ 15.4 C(1) @ @

Flash Point -65 F(1) Autoignition Temp. 428 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water insoluble(2) Hot Water Ethanol miscible(2)

Others: ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 0766

(2) 1492

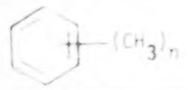
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Naphtha (Coal Tar) (284)

IUC Name Hi-flash naphtha

Common Names

Structural Formula



Molecular wt. Melting Pt. Boiling Pt. 149-216 C(1)

Density (Condensed) 0.862-0.892(1) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 100 F (C.C.)(1) Autoignition Temp. 900-950 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments Mixture of benzene, toluene, xylene, etc.(1)

References (1) 0766

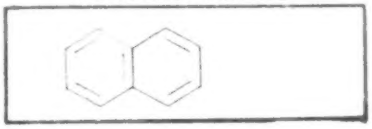
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Naphthalene (285)

IUC Name naphthalene

Common Names

Structural Formula



Molecular wt. 128.16

Melting Pt. 80.1 C(1)

Boiling Pt. 217.9 C(1)

Density (Condensed) 1.145 C(1) @

Density (gas) 4.42 @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 52.6 C(1) @ @

Flash Point 176 F(1)

Autoignition Temp. 979 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 0.9%(1) Upper 5.9%(1)

Solubility

Cold Water insoluble(2) Hot Water Ethanol soluble(2)

Others: benzene(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification I.A.T.A.: Flammable solid, yellow label(1)

Coast Guard Classification hazardous

Comments Sublimes at 217.9 C(1).

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name n-Pentane (323)

IUC Name n-pentane

Common Names

Structural Formula

$CH_3(CH_2)_3CH_3$

Molecular wt. 72.15 Melting Pt. -129.8 C(1) Boiling Pt. 36.1 C(1)

Density (Condensed) 0.626 @ 20/4 C(1) Density (gas) 2.48 @

Vapor Pressure (recommended 55 C and 20 C)

400 mm @ 15.5 C(1) @ @

Flash Point <-40 F(1) Autoignition Temp. 588 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.5%(1) Upper 7.8%(1)

Solubility

Cold Water insoluble(2) Hot Water Ethanol miscible(2)

Others: ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES WORKSHEET

H. M. Name Propylene (360)

IUC Name propene

Common Names

Structural Formula

$CH_2 = CHCH_3$

Molecular wt. 42.1 Melting Pt. -185 C(1) Boiling Pt. -47.7 C(1)

Density (Condensed) 0.581 @ 0 C(1) Density (gas) 1.5 @

Vapor Pressure (recommended 55 C and 20 C)

10 atm @ 19.8 C(1) @ @

Flash Point Autoignition Temp. 927 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.0%(1) Upper 11.1%(1)

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable gas label(1) Coast Guard Classification red gas label(1)

Comments

References (1) 0766

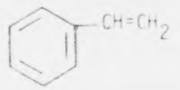
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Styrene (412)

IUC Name ethenylbenzene

Common Names vinyl benzene, cinnamene

Structural Formula



Molecular wt. 104.14 Melting Pt. -31 C(1) Boiling Pt. 146 C(1)

Density (Condensed) 0.9074 @ 20/4 C(1) Density (gas) 3.6 @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 88 F(1) Autoignition Temp. 914 F (1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.1%(1) Upper 6.1%(1)

Solubility

Cold Water slightly soluble(2) Hot Water Ethanol soluble(2)

Others: ether, acetone(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Tetrapropylene (429)

IUC Name

Common Names

Structural Formula

$(CH_2CHCH_2)_4$

Molecular wt. 168.32 Melting Pt. Boiling Pt.

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water insoluble Hot Water Ethanol

Others: benzene

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References

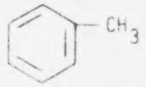
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Toluene (434)

IUC Name methyl benzene

Common Names phenyl methane

Structural Formula



Molecular wt. 92.13 Melting Pt. -95 C(1) Boiling Pt. 110.4 C(1)

Density (Condensed) 0.866 @ 20/4 C(1) Density (gas) 3.14(1) @

Vapor Pressure (recommended 55 C and 20 C)

36.7 mm @ 30 C(1) @ @

Flash Point 40 F (C.C.)(1) Autoignition Temp. 947 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.27%(1) Upper 7.0%(1)

Solubility

Cold Water insoluble(2) Hot Water Ethanol miscible(2)

Others: chloroform, ether, acetone(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Tripropylene (446)

IUC Name

Common Names

Structural Formula

$(CH_2CHCH_2)_3$

Molecular wt. 126.24 Melting Pt. Boiling Pt.

Density (Condensed) @ Density (gas) @ /

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Insoluble Hot Water Ethanol

Others: benzene

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Turpentine Oil (447)

IUC Name

Common Names spirit of turpentine

Structural Formula

$C_{10}H_{16}$

Molecular Wt. 136 Melting Pt. Boiling Pt. 154-170 C(1)

Density (Condensed) 0.854-0.868 @ 25/25 C(1) Density (gas) 4.84 @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 95 F (C.C.)(1) Autoignition Temp. 488 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 0.8%(1) Upper

Solubility

Cold Water insoluble(2) Hot water Ethanol soluble(2)

Others: benzene, chloroform(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification combustible liquid(1)

Comments

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name m-xylene (451)

IUC Name 1,3-dimethyl benzene

Common Names m-xylol

Structural Formula

Molecular wt 106.2 Melting Pt. -47.9 C(1) Boiling Pt. 139 C(1)

Density (condensed) 0.864 @ 20/4 C(1) Density (gas) 3.66(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 28.3 C(1) @ @

Flash Point Autoignition Temp. 982 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.1%(1) Upper 7.0%(1)

Solubility

Cold water insoluble(2) Hot water Ethanol miscible(2)

Others: ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 0766

(2) 1492

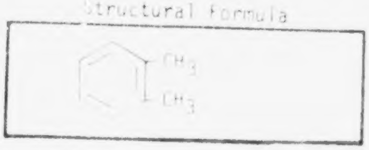
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name o-Xylene (451)

IUPAC Name 1,2-dimethyl benzene

Common Names o-xylol

Structural Formula



Molecular wt [illegible] Melting Pt. -29.5 C$^{(1)}$ Boiling Pt 144.4$^{(1)}$

Density (condensed) 0.880 @ 4 C$^{(1)}$ Density (gas) 3.66$^{(1)}$ @

Vapor Pressure (recommended 55 and 20 C)

mm 32.1$^{(1)}$ @ @

Flash Point [illegible] F$^{(1)}$ Autoignition Temp. 867 F$^{(1)}$

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.0%$^{(1)}$ Upper 6.0%$^{(1)}$

Solubility

Cold Water insoluble$^{(2)}$ Hot Water Ethanol miscible$^{(2)}$

Others: ether$^{(2)}$

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label$^{(1)}$ Coast Guard Classification red label$^{(1)}$

Comments

References (1) 0766

(2) 1492

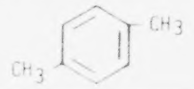
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name p-Xylene (451)

IUC Name 1,4-dimethyl benzene

Common Names p-xytol

Structural Formula



Molecular wt. 106.2    Melting Pt. 13.2 C(1)    Boiling Pt. 138.3 C(1)

Density (Condensed) 0.86(1) @ 20/4 C(1)    Density (gas) 3.66(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 27.3 C(1)    @    @

Flash Point 103 F (IOC)(1)    Autoignition Temp.

Flammability Limits in Air (wt %)    Lower    Upper

Explosive Limits in Air (wt. %)    Lower 1.1%(1)    Upper 7.0%(1)

Solubility

Cold water insoluble(2)    Hot water    Ethanol soluble(2)

Others: ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1)    Coast Guard Classification red label(1)

Comments

References (1) 0766

(2) 1492

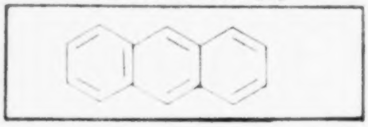
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Anthracene (466)

IUC Name anthracene

Common Names green oil

Structural Formula



Molecular wt. 178.22

Melting Pt. 217 C(1)

Boiling Pt. 345 C(1)

Density (Condensed) 1.25 @ 27/4 C(1)

Density (gas) 6.15 @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 145.0 C(1) @ @

Flash Point 250 F (C.C.)(1)

Autoignition Temp. 881 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 0.6(1) Upper

Solubility

Cold water insoluble(2)

Hot water

Ethanol slightly soluble(1)

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification

Coast Guard Classification

Comments Sublimes at 145 C(1)

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethane (493)

IUC Name ethane

Common Names dimethyl

Structural Formula

$CH_3CH_3$

Molecular wt. 30.07 Melting Pt. -172 C(1) Boiling Pt. -88.6 C(1)

Density (Condensed) 0.446 @ 0 C(1) Density (gas) 1.04 @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp. 959 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 3.0%(1) Upper 12.5%(1)

Solubility

Cold Water insoluble(2) Hot Water Ethanol slightly soluble(2)

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red gas label(1) Coast Guard Classification red gas label(1)

Comments

References (1) 0766
(2) 1492

PROFILE REPORT

# CARBOXYLIC ACIDS

Acrylic Acid (10), Adipic Acid (12), Benzoic Acid (57), Fatty Acids (197),
Formic Acid (202), Propionic Acid (356), Salicylic Acid (366).

## I. GENERAL

### Introduction

The carboxylic acids treated in this report have all been selected as probable candidate waste stream constituents for municipal disposal. These materials are similar in that most are commodity chemicals with low toxicity, well-defined and safe methods of industrial handling, and common methods of disposal. The carboxylic acids are, therefore, discussed as a class in this report.

For a discussion of the manufacture, uses and toxicological properties of the fatty acids and formic acid, one should refer to the Profile Reports on oleic acid (316) and sodium formate (390).

### Manufacture

Benzoic, adipic and propionic acids are manufactured by catalytic oxidation procedures. Benzoic acid is made from toluene, adipic acid from cyclohexanol, and propionic acid from propane, butane or a mixed feed. Salicylic acid is produced by the Kolbe-Schmitt reaction of sodium phenolate with carbon dioxide. Acrylic acid is made by several procedures including the hydrolysis of ethylene cyanohydrin; the destructive distillation of β-propriolactone; from acetylene, carbon monoxide and water in the presence of nickel carbonyl; the hydrolysis of acrylonitrile; and the catalytic oxidation of propylene.[1433,1501]

### Uses[1433,1506]

Benzoic acid is used as a food additive (44 , as a plasticizer (36 ), in alkyd resins (10 ) and in pharmaceuticals, flavorings and miscellaneous uses (10 ). The major use of adipic acid is the production of nylon 6/6 (88 ); other uses, such as esters for plasticizers and synthetic lubes, and in urethans account for the remainder. Propionic acid is used as a preservative and cattle feed additive in the form of the calcium and sodium salts (45 ), cellulose propionate plastics (30 ), and in herbicides and miscellaneous uses (6 ). Salicylic acid is used in aspirin (65 ), medicinals (15 ), as a rubber retarder and dye intermediate (10 ), and in miscellaneous uses (10 ). Acrylic acid is used in paint lattices ([illegible] ), textile manufacture (15 ), acrylic fiber (6 ), acrylic specialties (7 ), and in miscellaneous uses (14 ). Most acrylic acid is used as the ethyl, butyl and other esters.

## Physical and Chemical Properties

The physical and chemical properties of the compounds discussed in this report are included in the attached worksheets.

## 2. TOXICOLOGY$^{0766}$

With the exception of acrylic acid and formic acid (see Profile Report on sodium formate [390]), the carboxylic acids in this report show a very low order of toxicity. In fact, they are all used as preservatives and/or medicinals, and can be ingested directly with neutral or positive effects. Propionic acid is a relatively strong acid and its corrosive effects are similar to those of acetic acid. The sodium and calcium salts are innocuous. The toxic action of acrylic acid has not been investigated thoroughly. However, it is a very strong irritant to the eyes, mucous membranes and respiratory system.

## 3. OTHER HAZARDS

Under the proper conditions, such as the presence of oxygen or other polymerization initiator and heat, acrylic acid and its esters can polymerize violently.[0766,1433]

## 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

### Handling, Storage and Transportation

Acrylic, propionic and formic acids are all toxic to a certain extent due to the corrosive action of the liquid or vapors, especially in the sensitive areas of the eyes, mucous membranes and the respiratory tract. Thus, they should be handled in a well-ventilated area and protective clothing and respirators are recommended where necessary. In cases of accidental contact, all contaminated clothing should be removed and the skin washed with soap and water. The remaining compounds are solids and present no particular hazard.

These materials are shipped under a variety of U. S. Department of Transportation, U. S. Coast Guard and International Air Transport Association (IATA) regulations. Most regulations relate to the flammability and corrosiveness of these compounds. Information on safe handling and use of these compounds can be found in standard reference sources or manufacturers' Technical Data Sheets.

### Disposal/Reuse

Manufacturers who use the carboxylic acids as chemical intermediates recycle any unused material. Material used as food additives and medicinals is consumed by the public and not recoverable. A substantial amount of the acids in this group are used to produce plasticizers, resins, paint lattices or plastics. This material is not recoverable.

Many of the various manufacturing processes result in dilute carboxylic acid containing waste streams which have a high chemical and biological oxygen demand[0295,1543] and a low pH due to their acidity. They can be treated on site or discharged into the municipal sewer after pH adjustment.

Recommended provisional limits for the carboxylic acids discussed in this report are listed below.

| Contaminant in Air | Provisional Limit | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M$^3$ | |
| Acrylic acid | -- | 0.01 | Based on similar compounds |
| Adipic acid | -- | 0.25 | Based on similar compounds |
| Benzoic acid | -- | 0.25 | Based on similar compounds |
| Fatty acids | -- | 0.25 | Based on similar compounds |
| Formic acid | 0.05 | 0.09 | 0.01 TLV |
| Propionic acid | -- | 0.25 | Based on similar compounds |
| Salicylic acid | -- | 0.25 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limit ppm (mg/l) | Basis for Recommendation |
|---|---|---|
| Acrylic acid | 0.05 | Based on similar compounds |
| Adipic acid | 1.25 | Based on similar compounds |
| Benzoic acid | 1.25 | Based on similar compounds |
| Fatty acids | 1.25 | Based on similar compounds |
| Formic acid | 0.45 | Stokinger and Woodward Method |
| Propionic acid | 1.25 | Based on similar compounds |
| Salicylic acid | 1.25 | Based on similar compounds |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No.1 - Recycling

Manufacturers that use carboxylic acids as chemical intermediates recycle as much material as possible. In addition, a certain amount of contaminated acids are eligible for reprocessing. This is the method of choice wherever possible.

### Option No.2 - Treatment of Waste Water to Reduce Chemical and Biological Oxygen Demand

The carboxylic acids treated in this report have not only a low level of toxicity but they can be biodegraded very rapidly by unacclimated activated sludges. This is due in part to the fact that they are the same as or very similar to carboxylic acids present in normal sewage. Thus, the best method of disposal is via municipal sewage treatment plants provided the rate of discharge is uniform and the pH is in the proper range (6.0 to 9.0).

### Option No.3 - Incineration

Bulk quantities of contaminated carboxylic acids that can not be reprocessed or released by controlled dilution can best be disposed of by incineration. Since this will probably be an unusual occurrence, this is best done at industrial or municipal incineration sites.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

All of the wastes generated by the industries that produce and use the carboxylic acids discussed in this report can be handled by municipal or industrial disposal methods such as sewage treatment and incineration. Therefore, these materials are not judged to be candidate waste stream constituents requiring National Disposal Site treatment.

## 7. REFERENCES

0295. Land, H.F., ed., Industrial pollution control handbook. New York, McGraw Hill Book Company, 1971.

0766. Sax, I.R., Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. 22 v. New York, Interscience Publishers, 1963-1971.

1501. Faith, W.L., D.B. Keyes and R.L. Clark. Industrial chemicals. 3d ed. New York, John Wiley and Sons, Inc. 1965. 824 p.

1506. Chemical Profiles. Oil, paint and drug reporter profiles. New York, Schnell Publishing Company, Inc., 1970.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Acrylic Acid (10)

IUC Name propenoic acid

Common Names acroleic acid

Structural Formula

$CH_2=CHCO_2H$

Molecular wt. 72.06 Melting Pt. 14 C(1) Boiling Pt. 141 C(1)

Density (Condensed) 1.062(1) @ ____ ____ Density (gas) 2.5(1) @ ____ ____

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 39.0 C(1) ____ @ ____ ____ @ ____

Flash Point 130 F (O.C.)(1) Autoignition Temp. ____

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold Water miscible(2) Hot Water ____ Ethanol miscible(2)

Others: ether(2)

Acid, Base Properties ____

Highly Reactive with ____

Compatible with ____

Shipped in ____

ICC Classification ____ Coast Guard Classification ____

Comments ____

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Adipic Acid (12)

IUC Name 1,6-hexanedioic acid

Common Names 1,4-butane dicarboxylic acid

Structural Formula

$HO_2C(CH_2)_4CO_2H$

Molecular wt. 146.14 Melting Pt. 152 C[1] Boiling Pt. 337.5 C[1]

Density (Condensed) 1.360 @ 25/4 C[1] Density (gas) 5.04[1] @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 159.5 C[1] @ @

Flash Point 385 F (C.C.)[1] Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water soluble[2] Ethanol soluble[2]

Others: methanol, acetone[2]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) (76)
(2) (44)

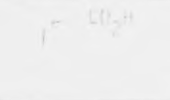
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Benzoic Acid (57)

IUC Name benzoic acid

Common Names

Structural Formula



Molecular wt. [illegible] Melting Pt. 121.7 C(1) Boiling Pt. 249 C(1)

Density (condensed) [illegible] @ Density (gas) 4.21(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 96 C(1) @ @

Flash Point [illegible] Autoignition Temp. 1061 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Hot water Ethanol soluble(2)

Others ether, acetone(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Sublimes at 96 C(1)

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Fatty Acids (197)

IUC Name ______

Common Names ______

Structural Formula

$C_nH_{2n+1}CO_2H$

Molecular wt. ______ Melting Pt. ______ Boiling Pt. ______

Density (Condensed) ______ @ ______ Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ ______ ______ @ ______

Flash Point [illegible] Autoignition Temp. 100 F

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt %) Lower ______ Upper ______

Solubility

Cold water insoluble Hot water ______ Ethanol soluble

Others: many common organic solvents.

Acid, Base Properties ______

Highly Reactive with ______

Compatible with ______

Shipped in ______

ICC Classification ______ Coast Guard Classification ______

Comments A series of naturally occurring acids of more than eight carbon atoms usually found as esters.

References (1) [illegible]

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Formic Acid (202)

IUC Name methanoic acid

Common Names

Structural Formula

$HCO_2H$

Molecular wt. 46.03

Melting Pt. 8.4 C(1)

Boiling Pt. 100.8 C(1)

Density (Condensed) [illegible] @ [illegible]

Density (gas) 1.59 @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ 24.0 C(1) @ @

Flash Point 156 F (69 C)(1)

Autoignition Temp. 1114 F(1)

Flammability Limits in Air (wt. %) Lower Upper

Explosive Limits in Air (wt. %) Lower 18%(1) (90% solution) Upper 57%(1) (90% solution)

Solubility

Cold water miscible(2) Hot water Ethanol miscible(2)

Others ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification corrosive, white label(1) Coast Guard Classification whit- label(1)

Comments dangerously caustic to the skin.(2)

References (1) 766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name: Propionic Acid (1356)

IUC Name: [illegible]

Common Names:

Structural Formula: [illegible]

Molecular wt. [illegible]
Melting Pt. [illegible]
Boiling Pt. 141 (1)

Density (condensed) [illegible] @
Density (gas) [illegible] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @
@
@

Flash Point [illegible]
Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water [illegible]
Hot water
Ethanol soluble(1)

Others: ether, chloroform

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification
Coast Guard Classification

Comments: Azeotrope with water, b.p. 99.98 C (1)

References (1) [illegible]

(2) [illegible]

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name [illegible]

IUC Name [illegible]

Common Names

Structural Formula

[illegible]

Molecular Wt. [illegible] Melting Pt. [illegible] Boiling Pt.

Density (condensed) [illegible] @ [illegible] Density (gas) [illegible] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible] @ @

Flash Point [illegible] Autoignition Temp. [illegible]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Hot water slightly soluble Ethanol soluble

Others [illegible], ether

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments [illegible]

References (1) [illegible]

(2) [illegible]

# PROFILE REPORT ON
# ALCOHOLS

Allyl Alcohol (14), Amyl Alcohol (31), Butanols (70,74,498), Cyclohexanol (132), Decyl Alcohol (139), Diethylene Glycol (154), Dipropylene Glycol (168), Ethanol (172), Ethylene Glycol (186,206), Octyl Alcohol (191), Furfural Alcohol (204), Glycerine (205), Isopropanol (228), Methanol (261), Methyl Amyl Alcohol (266), n-Propyl Alcohol (358), Propylene Glycol (361), Sorbitol (407), Triethylene Glycol (443).

## I. GENERAL

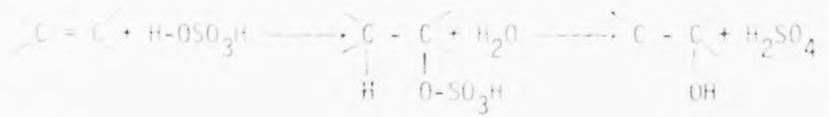
### Introduction

The alcohols treated in this report have all been selected as probable candidates for municipal disposal. These materials are similar in that most are commodity chemicals with relatively low toxicity, well-defined and safe methods of industrial handling and common methods of disposal. The alcohols are, therefore, discussed as a class in this report.

### Manufacture[1433,1506]

The alcohols treated in this report are manufactured by a wide variety of synthesis, some of which are specific to a given compound. The most important commercial wastes are discussed below.

Hydration of Alkenes. Alkenes can be hydrated in dilute sulfuric acid solution. The initial step is the addition of sulfuric acid across the double bond which is then hydrolyzed to the alcohol.



$$C = C + H\text{-}OSO_3H \longrightarrow \underset{H}{C} - \underset{O\text{-}SO_3H}{C} + H_2O \longrightarrow C - \underset{OH}{C} + H_2SO_4$$

Ethanol, as well as secondary and tertiary alcohols such as 2-propanol, 2-butanol, t-butanol and 2- and 3-pentanol (amyl alcohols), are manufactured in this way.

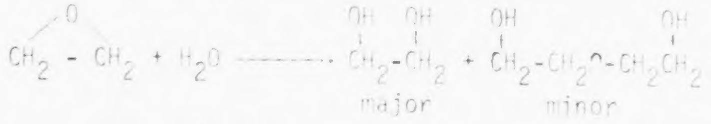
Reduction of Carbon Monoxide. The formation of methanol by the reaction of carbon monoxide with hydrogen at 250 to 400 C and 100 to 120 atm is a very important commercial process.

$$CO + 2H_2 \longrightarrow CH_3OH$$

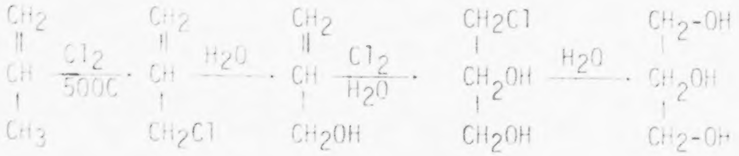
Hydrolysis of Organic Esters. The hydrolysis is catalyzed by both acids and bases. It is of considerable commercial importance for the production of alcohols from naturally occurring esters ($C_6$ and higher alcohols).

Reduction of Fatty Acids and Esters. The reduction of triglycerides, fatty acids or fatty acid esters by metallic sodium and a reducing alcohol or hydrogen in the presence of a specific catalyst is important in the manufacture of alcohols containing more than six carbon atoms. Sorbitol is manufactured from glucose in this manner.

Hydration of Alkylene Oxides. Ethylene and propylene glycol as well as their dimers are produced by the hydration of ethylene and propylene oxide. The dimeric alcohols diethylene glycol and dipropylene glycol are always produced as byproducts. The ratio of monomer to dimer decreases as the ratio of water to alkylene oxide decreases.



Glycerin or Glycerol is manufactured from propylene in the multi-step synthesis shown below. Approximately 60 percent of all glycerol is made this way, the remainder being produced from natural triglycerides.



The Oxo Process or Hydroformylation of the alkenes is important in the production of amyl alcohol, n-butanol, isobutanol,decyl alcohol, actyl ([illegible] (2-ethylhexanol)), and others. In this process the alkene is hydroformylated with carbon monoxide and hydrogen in the presence of a cobalt catalyst at 160 to 175 C and 1,500 to 4,000 psi. The resulting aldehyde is then hydrogenated to the alcohol at 150 C and 400 atm in the presence of a nickel or copper chromate catalyst.

### Uses[1433,1492,1506]

Solvents and Chemical Intermediates. The major uses of alcohols are as solvents and chemical intermediates, especially in the production of esters and aldehydes. The esters are used in plasticizers, lubricants, soaps, perfumes, flavors, cosmetics, etc. Further details can be found in the Profile Report on Esters.

Antifreeze and Cosmetics. Glycerin and the glycols find wide use as antifreeze (especially ethylene glycol) and as special agents in soaps, perfumes and other cosmetics.

Food Additives. Sorbitol is used as a food fortifier, especially as a sugar substitute for diabetics.

## 2. TOXICOLOGY[0766]

With the exceptions of methanol and allyl alcohol which are discussed below, the alcohols treated in this report are relatively non-toxic. All are irritants to the mucous membranes, particularly the eyes, nose and respiratory passages. The higher alcohols are generally more toxic, but the danger is reduced due to their lack of volatility and low solubility in water. Ingestion causes headache, nausea, vomiting, delirium and other well-known symptoms generally classed as "hangover". Repeated exposure can cause damage to the kidneys, liver and blood vessels. These effects have not been investigated thoroughly for many of the alcohols. Glycerol, sorbitol, ethanol, octyl alcohol, decyl alcohol and propylene glycol present only slight danger. Allyl alcohol is a very strong irritant and damage to the liver and kidneys occurs at much lower concentrations.

Methanol, in addition to the effects discussed above, has a special toxic effect on the nervous system, particularly the optic nerves and possibly the retinae. Once absorbed, methanol is eliminated so slowly that it can be regarded as a cumulative poison. It is detoxified in the body by oxidation to formaldehyde and formic acid, both of which are toxic.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) that have been established are as follows:

| Substance | TLV | | MAC |
|---|---|---|---|
| | ppm | mg/M$^3$ | ppm |
| Allyl Alcohol | 2 | 5 | 2 |
| Amyl Alcohol | - | - | - |
| Butanols | 100 | 300 | 100 |
| Cyclohexanol | 50 | 200 | - |
| Decyl Alcohol | - | - | - |
| Diethylene Glycol | - | - | - |
| Dipropylene Glycol | - | - | - |
| Ethanol | 1000 | 1900 | 1000 |
| Ethylene Glycol | - | - | 200 |
| Octyl Alcohol | - | - | - |
| Furfural Alcohol | 5 | 20 | - |
| Glycerin | - | - | - |
| Isopropanol | 400 | 980 | 400 |
| Methanol | 200 | 260 | 200 |
| Methyl Amyl Alcohol | 25 | 100 | - |
| n-Propyl Alcohol | 200 | 500 | - |
| Propylene Glycol | - | - | - |
| Sorbitol | - | - | - |
| Triethylene Glycol | - | - | - |

### 3. OTHER HAZARDS

No special hazards are connected with the handling of these compounds.[0766,1433] They are all somewhat flammable.

# 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

## Handling, Storage and Transportation

The alcohols treated in this report are all toxic to a certain extent due to the narcotic effects of high concentrations and irritating effects of the liquids or vapors, especially in the sensitive areas of the eyes, mucous membranes and respiratory tract. Thus, they should be handled in a well-ventilated area and protective clothing and respirators are recommended where necessary. In cases of accidental contact, all contaminated clothing should be removed and the skin washed thoroughly with soap and water.

These materials are shipped under a variety of U.S. Department of Transportation, U. S. Coast Guard and International Air Transport Association (IATA) regulations. Most regulations relate to the flammability of these compounds. Information on safe handling and use of these compounds can be found in standard reference sources or manufacturers' Technical Data Sheets.

## Disposal/Reuse

Manufacturers who use alcohols as chemical intermediates or process solvents recycle as much material as possible. Material used in perfumes, flavors, cosmetics, soaps, lubricants and antifreeze is consumed in small quantities by the public and is not recoverable. A substantial amount of the alcohols in this group is used to produce plasticizers, resins, paint lattices or plastics. This material is not recoverable.

Many of the various manufacturing processes result in dilute alcohol waste streams which have a high chemical and biological oxygen demand.[0285,1543] They can be treated on site or discharged into the municipal sewer.

Recommended limits for the compounds discussed in this report are listed below.

| Contaminant in Air | Provisional Limit ppm | Provisional Limit mg/M$^3$ | Basis for Recommendation |
|---|---|---|---|
| Allyl Alcohol | 0.02 | 0.05 | 0.01 TLV |
| Amyl Alcohol | - | 3.0 | Based on similar compounds |
| Butanols | 1.0 | 3.0 | 0.01 TLV |
| Cyclohexanol | 0.5 | 2.0 | 0.01 TLV |
| Decyl Alcohol | - | 1.0 | Based on similar compounds |
| Diethylene Glycol | - | 2.0 | Based on similar compounds |
| Dipropylene Glycol | - | 2.0 | Based on similar compounds |
| Ethanol | 10 | 19 | 0.01 TLV |
| Ethylene Glycol | - | 2.0 | Based on similar compounds |
| Octyl Alcohol | - | 1.0 | Based on similar compounds |
| Furfural Alcohol | 0.05 | 0.20 | 0.01 TLV |
| Glycerin | - | 2.0 | Based on similar compounds |
| Isopropanol | 4.0 | 9.8 | 0.01 TLV |
| Methanol | 2.0 | 2.6 | 0.01 TLV |
| Methyl Amyl Alcohol | 0.25 | 1.0 | 0.01 TLV |
| n-Propyl Alcohol | 2.0 | 5.0 | 0.01 TLV |
| Propylene Glycol | - | 2.0 | Based on similar compounds |
| Sorbitol | - | 2.0 | Based on similar compounds |
| Triethylene Glycol | - | 2.0 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limit ppm | Basis for Recommendation |
|---|---|---|
| Allyl Alcohol | 0.23 | Stokinger & Woodward Method |
| Amyl Alcohol | 15 | Based on similar compounds |
| Butanols | 15 | Stokinger & Woodward Method |
| Cyclohexanol | 10 | Stokinger & Woodward Method |
| Decyl Alcohol | 5 | Based on similar compounds |
| Diethylene Glycol | 10 | Based on similar compounds |
| Dipropylene Glycol | 10 | Based on similar compounds |
| Ethanol | 95 | Stokinger & Woodward Method |
| Ethylene Glycol | 1.0 | Based on similar compounds |
| Octyl Alcohol | 5.0 | Based on similar compounds |
| Furfural Alcohol | 1.0 | Stokinger & Woodward Method |
| Glycerin | 1.0 | Based on similar compounds |
| Isopropanol | 49 | Stokinger & Woodward Method |

| Contaminant in Water and Soil | Provisional Limit ppm | Basis for Recommendation |
|---|---|---|
| Methanol | 13 | Stokinger & Woodward Method |
| Methyl Amyl Alcohol | 5 | Stokinger & Woodward Method |
| n-Propyl Alcohol | 25 | Stokinger & Woodward Method |
| Propylene Glycol | 10 | Based on similar compounds |
| Sorbitol | 10 | Based on similar compounds |
| Triethylene Glycol | 10 | Based on similar compounds |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No.1 - Recycling

Manufacturers that use alcohols as chemical intermediates or process solvents recycle as much material as possible. In addition, a certain amount of contaminated alcohols are eligible for reprocessing. This is the method of choice wherever possible.

### Option No.2 - Treatment of Waste Water to Reduce Chemical and Biological Oxygen Demand

The alcohols treated in this report not only have a low level of toxicity but they can be biodegraded very rapidly by unacclimated activated sludges. This is due in part to the fact that most are either naturally occurring or components present in normal sewage. Thus, the best method of disposal is via municipal sewage treatment plants, provided the rate of discharge is uniform.

### Option No.3 - Incineration

Bulk quantities of contaminated alcohols that can not be reprocessed or released by controlled dilution can best be disposed of by incineration. Since this will probably be an unusual occurrence, this is best done at municipal or industrial incineration sites.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

All of the wastes generated by the industries that produce and use the alcohols treated in this report can be handled by municipal and industrial disposal methods such as sewage treatment and incineration. Therefore, the alcohols discussed in this report are not judged to be waste stream constituents requiring National Disposal Site treatment.

## 7. REFERENCES

0285 Lund, H.F., ed. Industrial Pollution Control Handbook. New York, McGraw-Hill Book Company, 1971.

0766 Sax, I.R. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433 Kirk-Othmer encyclopedia of chemical technology. 3d ed. 22 v. and suppl. New York, Interscience Publishers, 1966.

1492 Merck index of chemicals and drugs. 7th ed. Rahway, New Jersey, Merck Company, Inc., 1960. 1,634 p.

1506 Oil, paint and drug reporter profiles. New York, Schnell Publishing Company, Inc., 1970.

1543 Luzack, F.J. and M.B. Ettinger, Journal Water Pollution Control Federation, 32:1173-1200, 1960.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name [illegible]

IUC Name [illegible]

Common Names

Structural Formula

[illegible]

Molecular Wt. [illegible] Melting Pt. [illegible] Boiling Pt. [illegible]

Density (Condensed) [illegible] Density (gas) [illegible]

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible] @ [illegible]

Flash Point [illegible] Autoignition Temp. [illegible]

Flammability Limits in Air (wt %) Lower [illegible] Upper [illegible]

Explosive Limits in Air (wt %) Lower [illegible] Upper [illegible]

Solubility

Cold Water [illegible] Hot Water [illegible] Ethanol [illegible]

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References

HAZARDOUS WASTES PROPERTIES
WORKSHEET

[illegible] Name Allyl Alcohol (14)

IUC Name 2-propene-1-ol

Common Names

Structural Formula

$CH_2=CH-CH_2OH$

Molecular wt. 58.08 Melting Pt. -129 C[1] -50 C[1] Boiling Pt. 96-97 C[1]

Density (Condensed) 0.854 @ 20/4 C[1] Density (gas) 2.00[1] @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 10.5 C[1] @ @

Flash Point 70 F (21.1 C)[1] Autoignition Temp. 713 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.5[1] Upper 18[1]

Solubility

Cold Water miscible[2] Hot Water miscible[2] Ethanol miscible[2]

Others: miscible chloroform, ether, petroleum ether[2]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Polymerizes slowly on storage to a thick syrup.[2]

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name Amyl Alcohol (31)

IUC Name 1-pentanol

Common Names pentyl alcohol, n-amyl alcohol,
n-butyl carbinol

Structural Formula

$CH_3-CH_2-CH_2-CH_2-CH_2-OH$

Molecular wt. 88.15 Melting Pt. -79 C[1] Boiling Pt. 138.1 C[1]

Density (Condensed) 0.824 @ 20/20 C[1] Density (gas) 3.04[1] @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 13.6 C[1] 10 mm @ 44.9 C[1] @

Flash Point 100 F (C.C.)[2] Autoignition Temp. 572 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.2%[1] Upper 10% at 100 C[1]

Solubility

Cold Water 2.7 g/100 ml at 22 C[2] Hot water Ethanol miscible[2]

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification Combustible liquid

Comments There are three amyl alcohols; 1, 2 and 3-pentanol. All have similar properties.

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name: Amyl Alcohol (3)

IUC Name: 2-pentanol

Common Names: dl-sec-amyl alcohol, methyl propyl carbinol

Structural Formula

$CH_3-\overset{OH}{CH}-CH_2-CH_2-CH_3$

Molecular wt: 88.15  Melting Pt: -50 C[1]  Boiling Pt: 119.3 C[1]

Density (condensed): 0.81[1]  [illegible] @ 20 C[2]  Density (gas): 3.04[1] @

Vapor Pressure (recommended 55 C and 20 C)

@ @

Flash Point: 105 F (open cup)[1]  Autoignition Temp. 650 F to 725 F[1]

Flammability Limits in Air (wt %)  Lower  Upper

Explosive Limits in Air (wt. %)  Lower  Upper 9.0[1]

Solubility

Cold water [illegible] g/100 ml at 20 C[2]  Hot water  Ethanol miscible[2]

Others: miscible ether[2]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification  Coast Guard Classification

Comments

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name: Butanols (20,24,498)

IUC Name: 1-Butanol

Common Names: n-butyl alcohol

Structural Formula

$CH_3CH_2CH_2CH_2OH$

Molecular wt: 74.12 Melting Pt: -90 C[2] Boiling Pt: 117-118 C[2]

Density (Condensed): [illegible] 0.8098 [1] Density (gas): 2.55 [illegible]

Vapor Pressure (recommended 55 C and 20 C)

5.5 mm @ 20 C[1] @

Flash Point: 36-38 C[2] Autoignition Temp: 689 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.4 Upper 11.2

Solubility

Cold Water: 9.1 ml/100 ml at 25 C[2] Hot Water: Ethanol: miscible[2]

Others: miscible ether and many other organic solvents[2]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments: MCA warning label.

References (1) 0766
(2) 1497

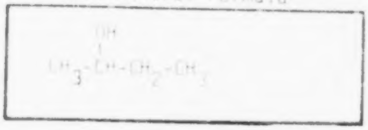
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name: Butanols (70,74,490)

IUC Name: 2-butanol

Common Names: methyl ethyl carbinol, sec-butyl alcohol

Structural Formula



$$CH_3-\overset{OH}{\overset{|}{C}H}-CH_2-CH_3$$

Molecular Wt.: 74.12

Melting Pt.: -89 C(1)

Boiling Pt.: 99.5 C(1)

Density (Condensed): 0.808 @ 20/4 C(1)

Density (gas): 2.55(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ [illegible](1) @

Flash Point: 75 F (24 C)(1)

Autoignition Temp.: 763 F(1)

Flammability Limits in Air (wt %): Lower Upper

Explosive Limits in Air (wt. %): Lower 1.7% at 100 C(2) Upper 9.8% at 100 C(2)

Solubility

Cold Water: [illegible] wt. %(2) Hot Water Ethanol: miscible(2)

Others: miscible in ether and other organic solvents.(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments: MCA warning label.

References (1) 0766

(2) 1492

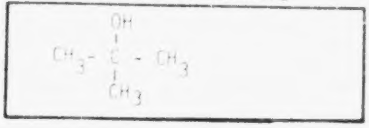
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Butanols (70,44,490)

IUC Name 2-methyl-2-propanol

Common Names trimethylcarbinol, tert-butanol

Structural Formula



$CH_3-\overset{OH}{\underset{CH_3}{C}}-CH_3$

Molecular wt. 74.12 Melting Pt. 25.3 C(1) Boiling Pt. 82.41 C(1)

Density (Condensed) 0.7887 @ 20/4 C(1) Density (gas) 2.55(1) @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ 24.5 C(1) @ @

Flash Point 52 F (C.C.)(1) Autoignition Temp. 892 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.4%(1) Upper 8.0%(1)

Solubility

Cold water soluble(2) Hot water Ethanol miscible(2)

Others: miscible ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments MCA warning label

References (1) 0766
(2) 1492

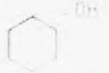
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Cyclohexanol (132)

IUC Name Cyclohexanol

Common Names Hexahydrophenol

Structural Formula



Molecular wt. 100.16 Melting Pt. -9 C(1) Boiling Pt. 161.5 C(1)

Density (Condensed) 0.9449 @ 25/4 C(1) Density (gas) 3.45 C(1) @

Vapor Pressure (Recommended 55 and 20 C)

1 mm @ 21.0 C(1) @ @

Flash Point 154 F (c.c.)(1) Autoignition Temp. 572 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water 3.6 wt.% at 20 C(2) Hot water Ethanol miscible(2)

Others: miscible ethyl acetate, linseed oil, petroleum solvents.(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Decyl Alcohol (138)

IUC Name 1-decanol

Common Names n-decyl alcohol, nonyl carbinol

Structural Formula

$CH_3-(CH_2)_8-CH_2OH$

Molecular Wt. 158.3 Melting Pt. 7 C(1) Boiling Pt. 231.0 C(1)

Density (Condensed) 0.8297 @20/4 C(1) Density (gas) 5.3(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @69.5 C(1) @ @

Flash Point 180 F(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water Ethanol soluble

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Diethylene Glycol (154)

IUC Name

Common Names diglycol

Structural Formula

$HO\text{-}CH_2\text{-}CH_2\text{-}O\text{-}CH_2CH_2\text{-}OH$

Molecular wt. 106.12 Freezing Pt. -8 C(1) Boiling Pt. 245.8 C(1)

Density (Condensed) 1.1184 @ 20/20 C(1) Density (gas) 3.66(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 91.8 C(1) @ @

Flash Point 255 F(1) Autoignition Temp. 444 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water miscible(2) Hot Water miscible(2) Ethanol miscible(2)

Others: miscible ether, acetone,(2) insoluble benzene and its homologues, chlorinated hydrocarbons.(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 1492

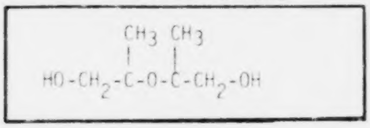
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Dipropylene Glycol (168)

IUC Name 2,2'-dihydroxyisopropyl ether

Common Names

Structural Formula



$$HO-CH_2-\overset{\overset{CH_3}{|}}{C}-O-\overset{\overset{CH_3}{|}}{C}-CH_2-OH$$

Molecular wt. 134.17 Melting Pt. Boiling Pt. 231.8 C(1)

Density (Condensed) 1.0252 @20/20 C(1) Density (gas) 4.63(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 73.8 C(1) @ @

Flash Point 280 F (O.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water soluble Hot Water Ethanol soluble

Others:

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Ethanol (172)

IUC Name

Common Names methyl carbinol, ethyl alcohol

Structural Formula

$CH_3-CH_2-OH$

Molecular wt. 46.07 Freezing Pt. -114.1 C(1) Boiling Pt. 78.32 C(1)

Density (Condensed) 0.7893 @ 20/4 C(1) Density (gas) 1.59(1) @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ 19 C(1) @ @

Flash Point 55 F(1) Autoignition Temp. 793 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 4.3%(1) Upper 19%(1)

Solubility

Cold water miscible(2) Hot water miscible(2) Ethanol

Others: miscible acetone, ether, chloroform.(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Ethylene Glycol (186,206)

IUC Name 1,2-ethanediol

Common Names glycol, glycol alcohol

Structural Formula

$HO-CH_2CH_2-OH$

Molecular wt. 62.1 Freezing Pt. -11.5 C(1) Boiling Pt. 197.5 C(1)

Density (condensed) 1.113 @ 25/25 C(1) Density (gas) 2.14(1) @

Vapor Pressure (recommended 55 C and 20 C)

0.05 mm @ 20 C(1) @ @

Flash Point 232 F [illegible](1) Autoignition Temp. 775 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 3.2 Upper

Solubility

Cold water miscible(1) Hot water miscible(2) Ethanol miscible(2)

Others: soluble lower alcohols, acetic acid, acetone, pyridine(2)
insoluble benzene and its homologues, chlorinated hydrocarbons(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments very hydroscopic(2)

References (1) 0766
(2) 1492

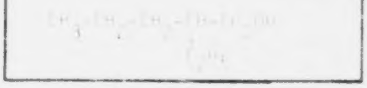
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name: Octyl Alcohol (292)

IUC Name: 2-ethyl-1-hexanol

Common Names: 2-ethylhexyl alcohol

Structural Formula



$$\begin{array}{l} CH_3-CH_2-CH_2-CH-CH_2OH \\ \qquad\qquad\qquad\quad C_2H_5 \end{array}$$

Molecular Wt: [illegible]    Melting Pt: -76 C(1)    Boiling Pt: 179-185.5 C(1)

Density (condensed): liquid [illegible](1)    Density (gas): 4.49(1) @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @

Flash Point: [illegible](2)    Autoignition Temp.:

Flammability Limits in Air (wt %)    Lower ______    Upper ______

Explosive Limits in Air (wt. %)    Lower ______    Upper ______

Solubility

Cold water: [illegible](2)    Hot water ______    Ethanol: miscible(2)

Others: miscible ether(2)

Acid, Base Properties ______

Highly Reactive with ______

Compatible with ______

Shipped in ______

ICC Classification ______    Coast Guard Classification ______

Comments ______

References (1) [illegible]

(2) 1432

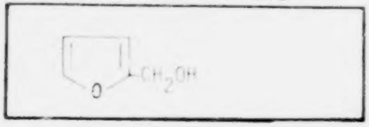
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Furfuryl Alcohol (204)

IUC Name

Common Names 2-furyl alcohol

Structural Formula



Molecular wt. 98.1 Melting Pt. -31 C(1) Boiling Pt. 171 C(750mm)(1)

Density (Condensed) 1.129 @ 20/4 (1) Density (gas) 3.37(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 31.8 C(1) @ @

Flash Point 167 F (O.C.)(1) Autoignition Temp. 915 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.8% (72-122 C)(1) Upper 16.3% (72-122 C)(1)

Solubility

Cold water miscible(2) Hot water Ethanol miscible(2)

Others

Acid, Base Properties easily resinified by acids.(2)

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments unstable in water.(2)

References (1) 0766

(2) 1492

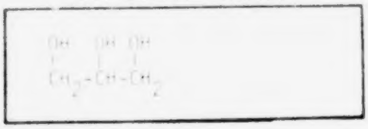
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name glycerin (203)

IUC Name 1,2,3-propanetriol

Common Names glycerol

Structural Formula



$$\begin{matrix} OH & OH & OH \\ | & | & | \\ CH_2 & -CH- & CH_2 \end{matrix}$$

Molecular wt. 92.09 Melting Pt. 17.9 C[1] Boiling Pt 290 C[1]

Density (condensed) 1.260 @ 20/4 C[1] Density (gas) 3.17[1] @

Vapor Pressure (recommended 55 C and 20 C)

0.0025 mm @ 50 C[1] @ @

Flash Point 320 F[1] Autoignition Temp. 739 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water miscible[2] Hot water miscible[2] Ethanol miscible[2]

Others: soluble ethyl acetate, ether;[2] insoluble benzene, chloroform, petroleum solvents.[2]

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments absorbs water, $H_2S$, HCN, and $SO_2$ readily.[2]

References (1) 0766
(2) 1492

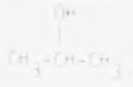
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Isopropanol (328)

IUC Name 2-propanol

Common Names isopropyl alcohol

Structural Formula



$$\overset{OH}{\underset{|}{}}\quad CH_3-CH-CH_3$$

Molecular wt. 60.09 Melting Pt. -88.5 C[1] Boiling Pt. 82.3 C[1]

Density (condensed) .7854 @ 20/4 C[1] Density (gas) 2.07[1] @

Vapor Pressure (recommended 55 C and 20 C)

33. mm @ 20 C[1] @ @

Flash Point 53 F[1] Autoignition Temp. 750 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower 2.0[1] Upper 12[1]

Solubility

Cold water miscible[2] Hot water miscible[2] Ethanol miscible[2]

Others: soluble ether, chloroform[2]

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1432

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Methanol (241)

IUC Name

Common Names methyl alcohol

Structural Formula

$CH_3OH$

Molecular wt 32.04 Freezing Pt. -97.8 C[1] Boiling Pt. 64.6 C[1]

Density (condensed) [illegible] @ [illegible] Density (gas) [illegible] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ @

Flash Point [illegible] Autoignition Temp. [illegible]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower [illegible] Upper 36.5[1]

Solubility

Cold Water [illegible] Hot Water [illegible] Ethanol miscible[2]

Others: miscible ether, benzene and most organic solvents [illegible]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 1498

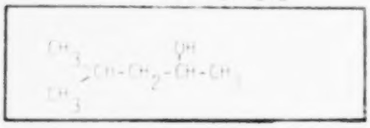
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Methyl Amyl Alcohol (766)

IUC Name 4-methyl-2-pentanol

Common Names methyl isobutyl carbinol

Structural Formula



$$\begin{matrix}CH_3 & & OH\\ & \!\!>CH-CH_2-CH-CH_3\\ CH_3 & & \end{matrix}$$

Molecular wt. 102.2 Freezing Pt. -90 C[1] Boiling Pt. 131.8 C[1]

Density (condensed) 0.8079 @ 20/20 C[1] Density (gas) 3.53[1] @

Vapor Pressure (recommended 55 C and 20 C)

3.5 mm @ 20 C[1] @ @

Flash Point 106 F[1] Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.0%[1] Upper 5.5%[1]

Solubility

Cold water insoluble Hot water Ethanol soluble

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name n-Propyl Alcohol (358)

IUC Name 1-propanol

Common Names ethyl carbinol

Structural Formula

$CH_3-CH_2-CH_2OH$

Molecular wt. [illegible] Melting Pt. -127 C[(1)] Boiling Pt. 97.19 C[(1)]

Density (condensed) 0.8044 @ 20/4 C[(1)] Density (gas) 2.07[(1)] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible][(1)] @ @

Flash Point [illegible] Autoignition Temp. 700 F[(1)]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.1[(1)] Upper 13.5[(1)]

Solubility

Cold water miscible[(2)] Hot water miscible[(2)] Ethanol miscible[(2)]

Others: miscible ether[(2)]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 3766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name: Propylene glycol (UHL)

IUC Name: 1,2-propanediol

Common Name:

Structural Formula

$\overset{OH}{CH_2}-\overset{OH}{CH}-CH_3$

Molecular wt. 76    Melting Pt.    Boiling Pt. 188.2 C(1)

Density (Condensed) [illegible] @ [illegible] (1)    Density (gas) 2.62(1) @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @    @

Flash Point [illegible]    Autoignition Temp. 790 F(1)

Flammability Limits in Air (wt %)    Lower    Upper

Explosive Limits in Air (wt. %)    Lower 2.6(1)    Upper 12.6(1)

Solubility

Cold water miscible(2)    Hot water miscible(2)    Ethanol miscible(2)

Others miscible acetone, chloroform(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification    Coast Guard Classification

Comments hydroscopic liquid.

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Sorbitol (407)

IUC Name

Common Names

Structural Formula

$HOCH_2-(CH_2OH)_4-CH_2OH$

Molecular wt. [illegible] Melting Pt. 97.5 C[1] Boiling Pt. dec.[1]

Density (condensed) 1.47 @ -5 C[1] Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water (% wt.)[2] Hot water Ethanol soluble hot[2]

Others: soluble alcohols, phenol, acetone, DMF, pyridine.[2]

Acid, Base Properties $K_a$ (17.5 C) = $2.5 \times 10^{-14}$, aqueous pH 7.0

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Triethylene glycol (504)

IUC Name 2,2'-Ethylene dioxydethanol

Common Names

Structural Formula

$(CH_2OCH_2CH_2OH)_2$

Molecular Wt. 150.17(1)  Melting Pt. -4.3 C(1)  Boiling Pt. 291.2 C(1)

Density (condensed) 1.122 @ 25 C(1) Density (gas) 5.17(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ NA(1)  @  @

Flash Point  Autoignition Temp. 700 F(1)

Flammability Limits in Air (wt %)  Lower  Upper

Explosive Limits in Air (vol %)  Lower 0.09  Upper 9.2(1)

Solubility

Cold water  Hot water  Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification  Coast Guard Classification

Comments

References (1) 0766

# PROFILE REPORT

## Allyl Chloride (15)

### 1. GENERAL

Allyl chloride (3-chloropropene) is a colorless, mobile liquid with a characteristic pungent odor. It is employed as a chemical intermediate, chiefly in the preparation of glycerine, resins, and fine chemicals. A wide variety of compounds may be formed from allyl chloride by addition to the olefinic double bond or by reaction of the chloride radical or both. Important intermediates derived from allyl chloride are glycerol chlorohydrins, epichlorohydrin, glycerol and glycidyl ethers, allylamines; and allyl ethers of trimethylolpropane. It finds use in the pharmaceutical field as a raw material for the production of allyl isothiocyanate (synthetic mustard oil), allyl substituted barbiturates (sedatives), and cyclopropane (anesthetic).[1759]

Allyl chloride is commercially synthesized directly by chlorinating propylene under conditions favoring substitution of a chlorine atom for a hydrogen atom on the saturated carbon; the double bond is preserved, and hydrogen chloride is produced as a byproduct. The reaction occurs only at elevated temperatures, the threshold being about 300 C. The reaction is carried out in an adiabatic reactor designed to provide rapid and intimate mixing. The usual reaction temperature range is 500 to 510 C at approximately 15 psig.[1433]

Allyl chloride is separated from other components of the reactor product stream by a series of fractionations. After initial removal of hydrogen chloride and propylene, the organic chloride fraction is separated in a conventional two-step distillation. The propylene is recycled and hydrogen chloride taken off for other use or to disposal. The heavy-boiling fraction is taken off as a bottom product, which, after further processing, has been found useful as a soil fumigant.[1433]

Commercial facilities for the manufacture of allyl chloride are operated by Shell Chemical Corporation and Dow Chemical Company.[1718] Physical/chemical properties are summarized in the attached worksheet.

## 2. TOXICOLOGY

Allyl chloride is a toxic chemical capable of causing severe tissue damage and death. Local skin contact causes irritation and burns; eye damage results from liquid or vapor exposure; absorption through the skin is rapid, with subsequent distribution throughout the system causing damage to internal tissues; inhalation of vapors results in irritation and lung damage, and ingestion is quite dangerous.[1433]

Concentrations of allyl chloride vapor of the order of 300 ppm and greater are profoundly irritating to the lungs. Sensory responses by unconditioned personnel during or following five minutes of exposure to vapor have been compiled[1760] below. The most frequent complaint following overexposure to the vapor has been referable to the eyes.

### SENSORY PERCEPTION LIMITS

| | |
|---|---|
| Threshold, $\text{Odor}_{50}$ | 3-6 ppm |
| Threshold, $\text{Odor}_{100}$ | 25 ppm |
| Threshold, Eye $\text{Irritation}_{50}$ | 50-100 ppm |
| Threshold, Nose $\text{Irritation}_{50}$ | <25 ppm |
| Threshold, Pulmonary $\text{Discomfort}_{50}$ | <25 ppm |

Although human intoxication by allyl chloride has not been seen to date, experimental data suggest that liver and kidney damage may occur. Human experience indicates that prolonged skin contact with allyl chloride can result in erythema and edema.[1760] The absorption of even small quantities of the liquid through the intact skin is usually accompanied by deep-seated pain in the contact area, and frequently repeated contacts with the liquid may result in the absorption of harmful quantities.[1758]

No cases of systemic intoxication have been reported coincident with the manufacture or industrial use of allyl chloride. However, it is to be expected that this highly reactive chemical will produce marked physiological effects if inhaled or otherwise taken into the body in excessive quantities.[1758]

## 3. OTHER HAZARDS

This material is highly dangerous when exposed to heat or flame. When heated to decomposition, it emits highly toxic fumes of chlorides. It is also known to react vigorously with oxidizing material. Allyl chloride is considered a moderate explosion hazard when exposed to flame.[0766]

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Storage, and Transportation[0766]

Allyl chloride must be stored away from heat, radiators and sunlight. Dry allyl chloride can be stored in steel for long periods of time without appreciable corrosion. Experiments show that cast iron, 18-8 stainless steel, monel, "Inconel," nickel, "Hastelloy AB," stoneware and red brass are corroded less than 0.020-inch per year at storage temperatures. Aluminum, however, is corroded more than 0.05-inch per year by dry allyl chloride under similar conditions. When allyl chloride contains more than a trace of water, corrosion of carbon steel becomes appreciable and localized attack is frequently observed. This is due to the hydrogen chloride evolved during hydrolysis.

The liquid must be kept off the skin and clothes. Where danger of spillage upon the body exist, workers should wear rubber gloves, goggles, aprons, and/or other protective clothing to avoid the consequences of spilling or splashing allyl chloride. Anti-splash face masks are also recommended.

Good ventilation must be maintained. Work must be conducted in a fume hood or with a closed system if possible, otherwise, sufficient ventilation must be used so that the odor of allyl chloride does not persist. If is should be necessary to enter an area in which the odor of allyl chloride is at all noticeable, it is recommended that a gas mask equipped with an "organic vapor" canister be used.

## Disposal/Reuse

Criteria for the disposal of allyl chloride in waste streams must take into account the products formed during neutralization. Generally, hydrogen chloride and hydrochloric acid are products of the current disposal procedure.

Current techniques(77) utilize incineration or land burial for the disposal of allyl chloride wastes. Both these methods are acceptable provided the recommended provisional limits for allyl chloride, hydrogen chloride and hydrochloric acid in the environment are not exceeded.

| Contaminant and Environment | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Allyl chloride in air | 0.01 ppm (0.03 mg/$M^3$) | 0.01 TLV |
| Hydrogen chloride in air | 0.05 ppm (0.07 mg/$M^3$) | 0.01 TLV |
| Hydrochloric acid in air | 0.05 ppm (0.07 mg/$M^3$) | 0.01 TLV |
| Allyl chloride in water and soil | 0.15 ppm (mg/l) | Stokinger and Woodward Method |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

Allyl chloride is expected to appear primarily as dilute organic waste and in much lesser amounts as concentrated waste and dilute aqueous waste. The processing options are briefly described in the following paragraphs together with recommendations as to their adequacy.

### Concentrated Ally Chloride[1771]

Most of the allyl chloride produced by Shell Chemical Company is for captive use and they have not experienced the need to dispose of concentrated waste. It was recommended that concentrated waste be incinerated with proper means of removing hydrogen chloride from the effluent stream. This is easily done through the use of aqueous or caustic scrubbers. High temperature incineration (1,800 F minimum, 2 seconds minimum) of allyl chloride with hydrogen chloride removal from the effluent gas is an acceptable means of disposing of this material.

### Dilute Organic Allyl Chloride Waste

Most production of allyl chloride at the Shell Chemical Company plant in Houston is used to produce allyl alcohol. Dilute organic allyl alcohol waste is incinerated. If dilute organic waste containing allyl chloride is generated, it is recommended that it be incinerated as discussed in the preceding section on concentrated allyl chloride.

### Dilute Aqueous Allyl Chloride Waste[1771]

Every effort is made to prevent allyl chloride from entering sewage because of its high flammability. Spills are allowed to evaporate when practical, or a chemical fog is used to suppress fumes and the material is collected with sawdust or absorbent clay. The sawdust and clay are combusted in incinerators equipped with particulate removal equipment and caustic or wet scrubbers for hydrogen chloride removal. The clay may then be reused as an adsorbent or buried in an approved landfill. If aqueous allyl chloride waste is generated, it is recommended that it be concentrated and incinerated with hydrogen chloride removal from the effluent gas or hydrolyzed to allyl alcohol and treated with acclimated activated sludge. It was reported[1771] that as much as 100 ppm allyl alcohol in water will not upset a well acclimated activated sludge.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Allyl chloride waste are expected to appear primarily as dilute organic waste streams and in much lesser amounts as concentrated waste and as dilute aqueous waste. Adequate means of handling the disposal of these wastes are located at manufacturing sites and industrial disposal facilities and represent proven industrial technology. Therefore, this material is not judged to be a candidate waste stream constituent for National Disposal Sites.

## 7. REFERENCES

0278. Code of federal regulations, Department of Transportation. Title 49, Parts 71-90. Washington, Superintendent of Documents, U. S. Government Printing Office, 1967. 794 p.

0766. Sax, N. I. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Company, 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. 22 v. and suppl. New York, Wiley-Interscience Publishers, 1963-1971.

1492. Merck and Company, Inc. The Merck index of chemicals and drugs. Rahway, New Jersey, 1960. 1,643 p.

1570. Chemical Rubber Company. Handbook of chemistry and physics. 47th ed. Cleveland, Chemical Rubber Company, 1966. 1,500 p.

1718. United States Tariff Commission. Synthetic organic chemicals, United States production and sales, 1970. TC Publication 479. Washington, U. S. Government Printing Office, 1972. 262 p.

1758. Shell Chemical Company. Safety data sheet, allyl chloride. Bulletin No. SC:57-79, New York, Jan. 1959. 6 p.

1759. Shell Chemical Company. Allyl chloride. Bulletin No. IC:69-22, New York, Apr. 1969. 2 p.

1760. Shell Chemical Company. Toxicity data sheet, allyl chloride. Bulletin No. SC:57-80, New York, Apr. 1958. 4 p.

1771. Personal communication. A. De Benedictus, Shell Chemical Company, to W. P. Kendrick, TRW Systems, May 26, 1972.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

[illegible] Name: Allyl Chloride

[illegible] Name: 3-chloropropene(1)

[illegible] Names: [illegible]propylene(1), [illegible], [illegible](1)

Structural Formula

$CH_2CHCH_2Cl$

Molecular Wt. [illegible] Melting Pt. -134.5 C Boiling Pt. 45 C(1)

Density (Condensed) 0.938 @ 20/4(1) Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ ______ ______

Flash Point [illegible](1) Autoignition Temp. ______

Flammability Limits in Air (wt %) Lower [illegible](4) Upper 11.2(4)

Explosive Limits in Air (wt. %) Lower 3.28(2) Upper 11.0(2)

Solubility

Cold Water: [illegible] Hot Water ______ Ethanol: Miscible(1)

Others: Miscible with ether(1), acetone(1), [illegible](1), chloroform(1)

Acid, Base Properties: Produces HCl on storage(2)

Highly Reactive with: Oxidizing material(2)

Compatible with: Nickel, monel and other chloride-resistant material(4)

Shipped in: Tank cars, 55-gallon drums

ICC Classification: Not listed(?) Coast Guard Classification ______

Comments: Mfg.(6) Dow Chemical Co., Shell Chemical Corporation
Rat in air: 300 ppm(3)

References: (1) 1135 (4) 1433 (7) 838
(2) 1765 (5) 1759 (8) 766
(3) 1436 (6) 1738

# PROFILE REPORT
# ALIPHATIC AMINES:

Aminoethylethanol Amine (18), n-Butylamine (75), Cyclohexylamine (134), Diethanolamine (150), Diethylamine (151), Diethylene Trimine (155), Diisopropanolamine (158), Dimethylamine (159), Ethanolamine (Monoethanolamine) (173,279), Ethylamine (Monoethylamine)(178), Ethylene Diamine (184), Hexamethylene Diamine (210), Isopropyl Amine (231), Methylamine (265), Morpholine (281), Propylamine (359), Triethanolamine (441), Triethylamine (442), Triethylene Tetramine (444), Trimethylamine (445), Urea (448).

## 1. GENERAL

### Introduction

The aliphatic amines treated in this report have all been selected as probable candidate waste stream constituents for industrial disposal. These materials are similar in that most are commodity chemicals with relatively low toxicity, good biodegradability, well-defined, safe methods of industrial handling and common methods of disposal. The aliphatic amines are, therefore, discussed as a class in this report.

### Manufacture

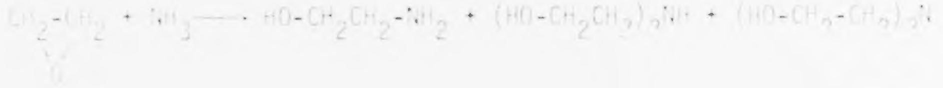
The compounds in this group are made by a wide variety of methods, some of which are specific to a given compound. The common industrial procedures representing over 95 percent of the total production of this group will be discussed here.[1718]

Most processes for manufacturing aliphatic amines involve the displacement of a reactive functional group from the appropriate aliphatic compound. The resulting mono substituted amine then competes with ammonia for unreacted starting material to produce a disubstituted amine which can then react further to produce a trisubstituted amine. Varying the proportions of the starting materials and reaction conditions can result in a preponderance of the mono-, di-, or tri-substituted product, but the selectivity to the desired amine is rarely greater than 70 to 80 percent, requiring each plant to have extensive purification facilities to separate the isomers.[1655,1501,1433,1434]

The reaction of ammonia with an alcohol or alkyl chloride produces alkyl amines. The alcohol-ammonia reaction (Equation 1) is a gas phase process that requires a dehydration catalyst, or a hydrogenation catalyst in the presence of hydrogen. The alkyl chloride-ammonia reaction (Equation 2) is a batch process that is carried out under pressure in an autoclave. The alcohol-ammonia reaction is favored in most cases since the alcohol is cheaper than the alkyl chloride and there is no problem with the disposal of ammonium chloride or hydrochloric acid.[1501,1433,1434]

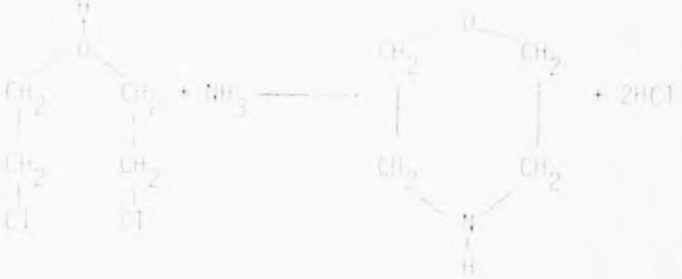
$$CH_3OH + NH_3 \longrightarrow CH_3NH_2 + (CH_3)_2NH + (CH_3)_3N + H_2O \qquad (1)$$

$$CH_3Cl + NH_3 \longrightarrow CH_3NH_2 + (CH_3)_2NH + (CH_3)_3N + NH_4Cl \qquad (2)$$

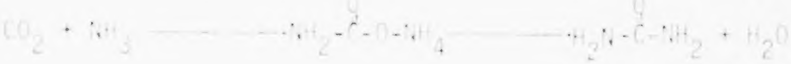


$$CH_2\text{-}CH_2\,(O) + NH_3 \longrightarrow HO\text{-}CH_2CH_2\text{-}NH_2 + (HO\text{-}CH_2CH_2)_2NH + (HO\text{-}CH_2\text{-}CH_2)_3N \qquad (3)$$

$$Cl\text{-}CH_2CH_2\text{-}Cl + NH_3 \longrightarrow H_2N\text{-}CH_2CH_2\text{-}NH_2 + H_2N\text{-}CH_2\text{-}CH_2\text{-}NH\text{-}CH_2CH_2\text{-}NH_2$$
$$+ H_2N\text{-}CH_2\text{-}CH_2\text{-}NH\text{-}CH_2\text{-}CH_2\text{-}NH_2\text{-}CH_2\text{-}CH_2\text{-}NH_2 \qquad (4)$$



(5)



$$CO_2 + NH_3 \longrightarrow NH_2\text{-}\overset{O}{\overset{\|}{C}}\text{-}O\text{-}NH_4 \longrightarrow H_2N\text{-}\overset{O}{\overset{\|}{C}}\text{-}NH_2 + H_2O \qquad (6)$$

$$CH_2{=}CH\text{-}CH{=}CH_2 \xrightarrow{Cl_2} ClCH_2\text{-}CH{=}CH\text{-}CH_2Cl \xrightarrow{NaCN}$$

$$NC\text{-}CH_2\text{-}CH\text{-}CH\text{-}CH_2\text{-}CN \xrightarrow{H_2} H_2N\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}NH_2 \qquad (7)$$

The reaction of aqueous ammonia and ethylene or propylene oxide at 50 to 60 C is used to manufacture the mono-, di-, and tri-ethanol or propanol amines, respectively (Equation 3). If ethylene dichloride and aqueous ammonia are reacted in an autoclave under pressure at 100 to 180 C, a mixture of ethylene diamide, diethylene triamine tetraamine and higher poly amines are produced (Equation 4). Morpholine is produced by reacting *sym*-dichloroethyl ether with ammonia under pressure at 50 C (Equation 5). Urea is produced by the reaction of carbon dioxide with ammonia at 150 to 200 C, and 150 to 300 atm pressure. Hexamethylene diamine is made by several processes, often in conjunction with sebacic acid. One of the most important routes is given below (Equation 7).[1501,1433,1434]

## Uses

The two amines that account for more than 80 percent of the total production in this group are urea and hexamethylenediamine. Urea is used as a fertilizer, cattle feed and in resins, while hexamethylenediamine is used in the production of nylon 6,6 and 6,10.[1506,1718,1433]

The remaining amines have a wide variety of uses as chemical intermediates and in formulations of various types. These include detergent manufacture (ethanol and isopropanol amines, isopropylamine, ethylenediamine, diethylene triamine and triethylene tetraamine); soaps, waxes and emulsifiers (alkylamines, ethylene diamines, etc.); corrosion inhibitors (alkylamines, cyclohexylamine); complexing and chelating agents (di-, tri-, and polyamines); in resins, and as reactive resin curing agents and polymerization catalysts; antioxidants; rubber chemicals; and insecticides and fungicides (methyl amine, ethylenediamine). The ethanol amines are used for gas scrubbing: dimethylamine is used in the production of dimethyl formamide and dimethyl acetamide; and morpholine is used in the production of optical brighteners for detergents. A detailed list of uses can be found in standard reference sources,[1433,1434,1506] and manufacturers data sheets.[2298,2299]

## Physical and Chemical Properties

The physical and chemical properties of the compounds discussed in this report are included in the attached worksheets.

## 2. TOXICOLOGY[0766,1433,2298,2299,2343]

The amines in this report are all relatively strong bases and thus share to some extent, the corrosive and damaging effect on tissue that are characteristic of the alkaline and alkaline earth hydroxides. Thus all liquid amines severely damage the eyes, ingestion causes severe internal corrosive injury, and prolonged contact with the skin can cause serious skin burns. In addition, amine vapors are painful and irritating to the eyes, nose, throat and respiratory system. However, most people find these vapors so repulsive that they will leave the area before serious injury occurs.

Repeated exposure to amines, especially diamines, and to a lesser extent, the ethanol amines, has been known to produce hypersensitivity, dermatitis and to precipitate allergenic and asthmatic reactions in some people.

The amines in this report are not particularly toxic systematically and while their toxicological properties have not been extensively investigated, it is felt that instances of ingestion or absorption of quantities of amines that do not cause local injury, present little danger to nonsensitive individuals. Chronic ingestion of amines that can be tolerated locally and chronic ingestion of those compounds with more than one amino group per molecule have been shown in some cases to cause liver and kidney damage.

Ingestion of cyclohexyl amines is reputed to cause convulsions in some cases. Urea has no importance as an industrial hazard.

The known Threshold Limit Values are listed below:

| Compound | TLV | |
|---|---|---|
| | ppm | mg/M$^3$ |
| Butylamine | 5 | 15 |
| Cyclohexylamine | 25 | 100 |
| Diethylamine | 25 | 75 |
| Dimethylamine | 10 | 18 |
| Ethylamine | 10 | 18 |
| Isopropylamine | 5 | 12 |
| Methylamine | 10 | 12 |
| Propylamine | N/A | N/A |
| Triethylamine | 25 | 100 |
| Trimethylamine | N/A | N/A |
| Ethylenediamine | 10 | 25 |
| Hexamethylenediamine | N/A | N/A |
| Dethylenetriamine | 1 | 4 |
| Triethylenetetramine | N/A | N/A |
| Monoethanolamine | 3 | 6 |
| Diethanolamine | N/A | N/A |
| Diisopropanolamine | N/A | N/A |
| Triethanolamine | N/A | N/A |
| Aminoethanol amine | N/A | N/A |
| Morpholine | 20 | 70 |
| Urea | N/A | N/A |

## 3. OTHER HAZARDS

The aliphatic amines burn cleanly without residue.[2297] However, when heated to decomposition, they may emit noxious, irritating and toxic fumes.[0766] In addition, these compounds will react vigorously to form potentially explosive mixtures with calcium and sodium hypochlorite and with alkaline and alkaline earth metals.[1569] Direct contact of allylamine vapors with mercury can cause an explosion. Amines can cause the explosive decomposition of maleic anhydride.[1609] These compounds have a wide range of flammability and tendency to explode (noted in the respective worksheets); none are shock-sensitive or subject to detonation.[0766]

## 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

### A. Handling, Storage and Transportation

The aliphatic amines are all toxic to a certain extent by inhalation or skin contact. In addition, they are very corrosive to eyes and can cause minor to severe primary skin irritation on contact. Thus, these materials should be handled in a well-ventilated area and protective clothing and respirators are recommended where necessary. In cases of accidental contact, all contaminated clothing should be removed instantly and the skin washed thoroughly with soap and water.[0766]

Storage of these materials should be in cool, dry, well-ventilated areas, away from acute fire hazards. Materials with low boiling points should be protected from excessive heat and against sudden rise in temperature. Liquid materials that can solidify should be liquified completely before transfer in order to obtain uniform material.[2298,2299]

These materials are shipped under a variety of U.S. Department of Transportation, U. S. Coast Guard and International Air Transport Association (IATA) regulations. Most regulations relate to the flammability and volatility of the compounds. Information on safe handling and use of these compounds can be found in the Chemical Data Sheets published by the Manufacturing Chemists Association,[2340,2341,2342] standard reference sources,[0766,1433,1434] or manufacturers' technical data sheets.[2298,2299,2340,2341,2342]

## Disposal/Reuse

Commercial operators use aliphatic amines in literally hundreds of applications. In many cases, the amine is used as an additive to improve the performance of a given formulation. Disposal of amines used in this manner is best considered in respect to the major component of the formulation. Since many of these formulations are sold as consumer items, detrimental environmental effects can not be controlled except by reformulation. Aliphatic amines are also used as chemical intermediates in the production of detergents, emulsifiers, soaps, waxes, nylon, resins, catalysts, insecticides, fungicides, optical brighteners and other chemicals. In these cases, the chemical form of the amines is changed and disposal is best considered in respect to the new compound.[1506,1433,1434,2298,2299]

In manufacture, enormous amounts of research have gone into determining the reaction conditions that allow production of a reaction mixture of mono-, di-, and tri-amines that corresponds to sales demand. Unfortunately, this is not always the case and a given manufacturer must store the unused amine until a use can be found for it. This represents a serious potential disposal problem.[1433,1501,1718]

The manufacture of urea has been developed to the point where there is close to 100 percent utilization of all raw materials and reaction products as various grades of animal feed and fertilizer.[314]

All the compounds treated in this report, with the exception of urea, require extensive purification to separate the various products. Usable or potentially usable products generally account for more than 90 to 95 percent of the total raw material. This material or "heavy bottoms" is presently disposed of by incineration, landfill, deep well injection or is processed to reduce biological and chemical oxygen demand.[1433,1501]

Most, if not all, manufacturing procedures for the production and use of amines produce dilute waste streams of nitrogen containing materials. These materials are presently disposed of by discharge into municipal sewer systems or rivers, with or without pre-treatment to reduce chemical and biological oxygen demand, or by deep well injection. Since amines have strong obnoxious odors, the pH of the effluent must be controlled to prevent escape of the amine into the atmosphere.

Recommended provisional limits for the aliphatic amines discussed in this report are listed below:

| Contaminant in Air | Provisional Limit | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M$^3$ | |
| Methylamine | 0.10 | 0.12 | 0.01 TLV |
| Ethylamine | 0.10 | 0.18 | 0.01 TLV |
| Propylamine | - | 0.12 | Based on similar compounds |
| Isopropylamine | 0.05 | 0.12 | 0.01 TLV |
| Butylamine | 0.05 | 0.15 | 0.01 TLV |
| Dimethylamine | 0.10 | 0.18 | 0.01 TLV |
| Diethylamine | 0.25 | 0.75 | 0.01 TLV |
| Trimethylamine | - | 1.0 | Based on similar compounds |
| Triethylamine | 0.25 | 1.0 | 0.01 TLV |
| Cyclohexylamine | - | 0.1 | Based on similar compounds |
| Ethyleneamine | 0.005 | 0.01 | 0.01 TLV |
| Ethylenediamine | 0.10 | 0.25 | 0.01 TLV |
| Hexamethylenediamine | - | 0.04 | Based on similar compounds |
| Diethylenetriamine | 0.01 | 0.04 | 0.01 TLV |
| Triethylenetetramine | - | 0.04 | Based on similar compounds |
| Monoethanolamine | 0.03 | 0.06 | 0.01 TLV |
| Diethanolamine | - | 0.06 | Based on similar compounds |
| Diisopropanolamine | - | 0.06 | Based on similar compounds |
| Triethanolamine | - | 0.06 | Based on similar compounds |
| Aminoethanol amine | - | 0.06 | Based on similar compounds |
| Morpholine | - | 0.06 | Based on similar compounds |
| Urea | - | 0.06 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Methylamine | 0.60 | Stokinger & Woodward Method |
| Ethylamine | 0.90 | Stokinger & Woodward Method |
| Propylamine | 0.60 | Based on similar compound |
| Isopropylamine | 0.60 | Stokinger & Woodward Method |
| Butylamine | 0.75 | Stokinger & Woodward Method |
| Dimethylamine | 0.90 | Stokinger & Woodward Method |

(Cont'd)

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Diethylamine | 3.75 | Stokinger & Woodward Method |
| Trimethylamine | 5.0 | Based on similar compounds |
| Triethylamine | 5.0 | Stokinger & Woodward Method |
| Cyclohexylamine | 0.5 | Based on similar compounds |
| Ethyleneimine | 0.05 | Stokinger & Woodward Method |
| Ethylenediamine | 1.27 | Stokinger & Woodward Method |
| Hexamethylenediamine | 0.20 | Based on similar compounds |
| Diethylenetriamine | 0.20 | Stokinger & Woodward Method |
| Triethylenetetramine | 0.20 | Based on similar compounds |
| Monoethanolamine | 0.30 | Stokinger & Woodward Method |
| Diethanolamine | 0.30 | Based on similar compounds |
| Diisopropanolamine | 0.30 | Based on similar compounds |
| Triethanolamine | 0.30 | Based on similar compounds |
| Aminoethanol amine | 0.30 | Based on similar compounds |
| Morpholine | 0.30 | Based on similar compounds |
| Urea | 0.30 | Based on similar compounds |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No.1 - Reformulation of Products to Reduce Environmental Impact

A large portion of the amine compounds treated in this report are consumer products or are used industrially in such a manner that they are discharged directly into the environment either during or directly after use.[1433,1434,2298,2299] Since conventional waste management practices are very difficult or impossible to apply under these conditions, reformulation with or use of alternative materials that have less environmental impact is recommended when necessary.

### Option No.2 - Treatment of Waste Water and Water Soluble By-products to Reduce Biological and Chemical Oxygen Demand

Aliphatic amine compounds, as well as by-products of use and production, can be chemically and biologically degraded very easily, making this method the ideal way for waste disposal.[1543] Depending on the quality and quantity of effluent that must be treated, treatment can be carried out at the manufacturing site and/or by the municipal waste treatment system. Final discharge should meet water quality standards.

### Option No. 3 - Incineration

Badly contaminated amines that cannot be reclaimed, as well as by-products that cannot be sold and unusable end-products, can be disposed of by incineration. A scrubber and/or catalytic or thermal unit may be necessary to reduce $NO_x$ emissions to required levels.

### Option No. 4 - Landfill of Residue and Sludges Obtained During Manufacturing or Use

Deposit or landfill of amine-containing waste presents a serious long-term environmental hazard to man, animals and fish. These materials are toxic and to some extent water soluble. Biodegradation of polymers or polyamines will further increase mobility by molecular weight reduction. Thus, landfill disposal of these wastes represents an excessive, long-term threat to underground water supplies and must be considered much less acceptable than Option No.3 (incineration). Option No.4 is acceptable only when landfill sites meet California Class 1 specifications.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Most of the wastes generated by the industries that produce and use the materials discussed in this report can be handled and treated locally by incineration and conventional water treatment. Wastes presently landfilled should be incinerated unless the landfills meet California Class I specifications. Since adequate industrial disposal methods are currently being utilized by most manufacturers, users and industrial waste disposal facilities, the aliphatic amines discussed in this report are not judged to be candidate waste stream constituents for National Disposal Site treatment.

## 7. REFERENCES

0314. Jones, H.E., Environmental control in the organic and petrochemical industries. Park Ridge, New Jersey, Noyes Data Corporation, 1971.

0766. Sax, I.R., Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 3d ed. 22 V. New York, Interscience Publishers, 1966.

1434. Kirk-Othmer encyclopedia of polymer science and technology. 12 V. New York, Interscience Publishers, 1964-1970.

1501. Faith, W.L., D.B. Keyes, and R.L. Clark. Industrial chemicals. 3d ed. New York, John Wiley and Sons, Inc.,1965. 824 p.

1509. Oil, paint and drug reporter profiles. New York, Schnell Publishing Company, Inc., 1970.

1543. Ludzack, F.J., M.B. Ettinger. Chemical structures resistant to aerobic chemical stabilization. Journal Water Pollution Control Federation. 32(11):1173-1200. Nov. 1960.

1569. Manual of hazardous chemical reactions. Boston National Fire Protection Association, 1971. 308 p.

1655. Fieser, L.F. and M. Fieser, Organic chemistry. 3d ed. Boston, D.C. Heath & Company, 1956. p 145-160, 644-655.

1710. Synthetic organic chemicals, U.S. production and sales. U.S. Government Printing Office. Washington, D.C., Publication TC-479, 260 p.

2298. Technical data sheet for alkyl and alkylene amines. New York, Union Carbide Chemicals Company, 1960. 48 p.

2299. Technical data sheet for alkanolamines and morpholines. New York, Union Carbide Chemicals Company, 1960. 53 p.

2340. Methyl amines chemical safety data sheet., SD-57. Washington., Manufacturing Chemists Association. 1955. 20 p.

2341. Isopropylamine chemical safety data sheet, SD-72. Washington., Manufacturing Chemists Association, 1959. 13 p.

2342. Diethylene triamine chemical safety data sheet, SD-76. Washington., Manufacturing Chemists Association, 1959. 15 p.

2343. Gleason, M.M., R.E. Gusselin and H.C. Hodge, Chemical toxicology of commercial products., Baltimore, The Williams and Wilkins Company, 1960. 53 p.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Aminoethylethanol amine (18)

IUC Name

Common Names 2-aminoethylethanol amine
N-(2-hydroxyethyl)ethylenediamine
2-amino-2' hydroxydiethylamine

Structural Formula

$NH_2CH_2CH_2NHCH_2CH_2OH$

Molecular wt. 104.16 Melting Pt. Boiling Pt. 243.7[1]

Density (Condensed) 1.0304 @ 20/20[1] Density (gas) 3.59 @

Vapor Pressure (recommended 55 C and 20 C)

<0.01 mm Hg @ 20[1] @ @

Flash Point 265 F (O.C.)[1] Autoignition Temp. 695 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Combustible with non-toxic residue[2]

Solubility

Cold water miscible[3] Hot water Ethanol miscible[3]

Others: slightly soluble in benzene, ligroin[3]

Acid, Base Properties approx. neutral

Highly Reactive with can react with oxidizing materials[1], highly flammable,[2]

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 766
(2) 2297
(3) 1570

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H.W. Name Butylamine (76)

IUC Name 1-aminobutane

Common Names 1-aminobutane

Structural Formula

$CH_3(CH_2)_2CH_2NH_2$

Molecular wt. 73.14 Melting Pt. [illegible](4) Boiling Pt. 77.8 C(4)

Density (condensed) [illegible] Density (gas) [illegible](1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 45 F Autoignition Temp. 564 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.7% Upper 9.8%(1)

Combustible with non-toxic residue

Solubility

Cold water [illegible] Hot water Ethanol miscible(3)

Others: miscible with ether(3)

Acid, Base Properties [illegible]

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid,red label(5) Coast Guard Classification

Comments

References (1) 1766
(2) 2797
(3) 1492
(4) 1570
(5) 2268

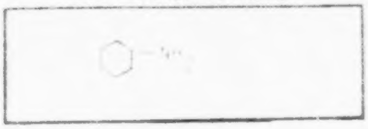
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. No. Name Cyclohexylamine (134)

IUC Name Aminocyclohexane

Common Names Hexahydroaniline

Structural Formula



Molecular Wt. [illegible] Melting Pt. -17.7 C[1] Boiling Pt. 134.5 C[1]

Specific Gravity (condensed) [illegible] @ 25/25 C Density (gas) 3.42 (Air=1)[1] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible] mm[1] [illegible] @ 36 mm[2] @

Flash Point [illegible] Autoignition Temp. 560 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Moderate fire hazard when exposed to heat or flame[1]

Solubility

Cold water miscible[2] Hot water miscible[2] Ethanol miscible[2]

Others: miscible - all common organic solvents[2]

Acid, Base Properties strong base[1]

Highly Reactive with oxidizing materials[1]

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments forms azeotrope with H2O [illegible] gives off toxic fumes on decomposition (NOx)[1]

References (1) 766
(2) 1570
(3) 1493

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Diethanolamine (150)

IUC Name 2,2'-iminodiethanol

Common Names Di(2-hydroxyethyl) amine(1)
diethylolamine(3), bis(hydroxyethyl)amine(4)
2,2'-dihydroxydiethylamine(3)
N-(hydroxyethyl)[illegible]

Structural Formula

$(HOCH_2CH_2)_2NH$

Molecular wt 105.14 Melting Pt. 28 C(1) Boiling Pt. 269.1 C(decomp)(1) 238-40 C(4)

Density (Condensed) 1.0919 @ 30/20 C(1) Density (gas) 3.65(1) @

Vapor Pressure (recommended 55 C and 20 C)

5 mm Hg @ 138 C(1) @ @

Flash Point 280 F (O.C.)(1) Autoignition Temp. 1224 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Combustible with non-toxic residue(2)

Solubility

Cold water very soluble(3) Hot water Ethanol very soluble(3)

Others: slightly soluble in ether, benzene(3), miscible in methanol, acetone(4)

Acid, Base Properties moderate base(4) pH of 0.1N aq.soln.: 11.0(4)

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 2297
(3) 1570
(4) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Diethylamine (131)

IUC Name

Common Names diethylamine

Structural Formula

$(C_2H_5)_2NH$

Hydrate m.p. - 19 (5)

-48 C(4) 56.3 C(4)

Molecular wt. 73.14 Melting Pt. -38.9 C(1) Boiling Pt. 55.5 C(1)

Density (Condensed) 0.71(g/cc) @ 20/20 C(1) Density (gas) 2.53 @
(Air=1)

Vapor Pressure (recommended 55 C and 20 C)

194 mm @ 20 C(2) 620 mm @ 50 C(2) @

Flash Point [illegible] (1) Autoignition Temp. 594 C(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water very soluble(3) Hot water Ethanol miscible(4)

Others: sol. in ether(3)

Acid, Base Properties strongly alkaline(5)

Highly Reactive with

Compatible with

Shipped in tank cars, trucks, drums(3)

ICC Classification Coast Guard Classification

Comments colorless liquid(1)

References (1) 0766
(2) 2298
(3) 0281
(4) 1570
(5) 1492

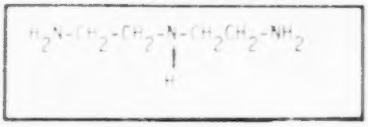
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Diethylene triamine (155)

IUC Name

Common Names 2,2'-diaminodiethylamine

Structural Formula



$H_2N-CH_2-CH_2-\underset{H}{\underset{|}{N}}-CH_2CH_2-NH_2$

Molecular wt. 103.17 Melting Pt. -39 C(1) Boiling Pt. 208 C(1)

Density (condensed) .9542 @ 20 C(1) Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

2 mm @ 20 C(2) 10 mm @ 86 C(2) @

Flash Point 215 F(2) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water miscible(1) Hot water miscible(1) Ethanol miscible(1)

Others: insoluble ether(1) soluble ligroin(1)

Acid, Base Properties basic

Highly Reactive with

Compatible with

Shipped in 1 gal tin cans, 5 and 55 gal iron drum(2).

DOT Classification None(2) Coast Guard Classification

Comments

References (1) 1570

(2) 2298

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Diisopropanolamine (158)

IUC Name

Common Names

Structural Formula

$[CH_3CH(OH)CH_2]_2$ NH

Molecular wt. 133.19 Melting Pt. 42 C$^{(1)}$ Boiling Pt. 249 C$^{(1)}$

Density (Condensed) 0.9890 @ 45/20 C$^{(1)}$ Density (gas) 4.59$^{(1)}$ @

Vapor Pressure (recommended 55 C and 20 C)

<0.01 mm @ 20 C$^{(2)}$ 10 mm @ 133 C$^{(2)}$ 50 mm @ 167 C$^{(2)}$

Flash Point 260 F(O.C.)$^{(1)}$ Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water 87% at 20 C Hot Water Ethanol miscible

Others:

Acid, Base Properties moderately basic

Highly Reactive with

Compatible with

Shipped in iron or steel containers; stainless or aluminum where lack of color is importan
important$^{(2)}$.

ICC Classification none Coast Guard Classification

Comments

References (1) 0766
(2) 2299

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name Dimethylamine (159)

IUC Name

Common Names Dimethylamine

Structural Formula

$(CH_3)_2NH$

Molecular wt. 45.08 Melting Pt. -92 C(1) Boiling Pt. 6.88 C(1)

Density (condensed) 0.680 g [illegible] @ [illegible]4(1) Density (gas) 1.55(1) (Air=1) @

Vapor Pressure (recommended 55 C and 20 C)

2 atm @ 10 C(3) 5 atm @ 53.9 C(2) @

Flash Point 21 F [illegible](1) Autoignition Temp. 756 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.8% Upper 14.4%(1)

Solubility

Cold Water very(2) Hot Water very(2) Ethanol soluble(2)

Others: soluble ether, tetrahydrofuran(2)

Acid, Base Properties basic

Highly Reactive with

Compatible with

Shipped in

ICC Classification MCA warning label flammable gas; red label Coast Guard Classification red label

Comments

References (1) 0766
(2) 1492
(3) 1570

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H.M. Name Ethylamine (176)

IUC Name aminoethane

Common Names Ethylamine, aminoethane, monoethylamine

Structural Formula

$CH_3CH_2NH_2$

Molecular Wt. 4[illegible] Melting Pt. -80.6 C(1) Boiling Pt. 16.6 C(1)

Density (Condensed) [illegible] @ [illegible] Density (gas) 1.56(1) @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] mm @ [illegible] [illegible] mm @ [illegible] 1 atm @ 16.6 C(4)

5 atm @ 65.3 C(4)

Flash Point Autoignition Temp. 723 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water miscible Hot Water Ethanol miscible

Others: miscible ether

Acid, Base Properties alkaline

Highly Reactive with

Compatible with carbon steel

Shipped in carbon steel tank cars, trucks, drums(2)

ICC Classification flammable liquid, red label IATA red label Coast Guard Classification

Comments colorless liquid, strong ammoniacal odor(1)

References (1) 0766
(2) 2295
(3) 1670
(4) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethylene diamine (184)

IUC Name 1,2-diaminoethane

Common Names ethylenediamine, [illegible] ethanediamine

Structural Formula

$NH_2CH_2CH_2NH_2$

Molecular Wt [illegible]

Melting Pt. 8.5 C[1]

Boiling Pt. 117.2 C[1]

Density (condensed) [illegible] @ [illegible]

Density (gas) 2.07[1] (Air=1) @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible]

52 mm @ 50 C(3)

@

Flash Point [illegible]

Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower Upper

Solubility

Cold water miscible[1]

Hot water

Ethanol miscible(3)

Others slightly soluble ether, insoluble benzene(4)

Acid, Base Properties alkaline[4]

Highly Reactive with copper and copper alloys.[2]

Compatible with aluminum, steel(2).

Shipped in tank cars, truck, drums, carbon steel(2).

ICC Classification

Coast Guard Classification

Comments forms hydrate m.p. 10 C, bp. 118 C(5).

References (1) 2766
(2) 2238
(3) 1570
(4) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H.M. Name Isopropylamine (231)

IUC Name 2-aminopropane

Common Names [illegible]

Structural Formula

$(CH_3)_2CHNH_2$

Molecular Wt. [illegible] Melting Pt. -101 C(1) Boiling Pt. 31.7 C(1)

Density (Condensed) [illegible] @ [illegible](1) Density (gas) 2.03(2) @
Air=1.0

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ @

Flash Point [illegible] Autoignition Temp. 756 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.33(1) Upper

Solubility

Cold Water soluble(3) Hot Water soluble(3) Ethanol soluble(3)

Others: soluble in ether(3)

Acid, Base Properties basic

Highly Reactive with

Compatible with

Shipped in: Tank cars, truck, drums

ICC Classification Coast Guard Classification

Comments colorless, highly volatile, strong irritating odor(4)

References (1) 0766
(2) [illegible]
(3) 1570
(4) 2298

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name Methylamine (263)

IUC Name aminoethane

Common Names methylamine

Structural Formula

$CH_3N$

Molecular wt. 31.1 Melting Pt. -93.5 C(1) Boiling Pt. -6.79 C(1)

Density (condensed) 0.662 @ 20/4 C(1) Density (gas) 1.07(1) (Air=1) @

Vapor Pressure (recommended 55 C and 20 C)

1396 mm @ 20 C(1) 5170 mm @ 52 C(3) @

Flash Point 0 F (1) Autoignition Temp. 806 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower 4.95%(1) Upper 20.75%(1)

Solubility

Cold water very soluble(1) Hot water very soluble(3) Ethanol soluble

Others

Acid, Base Properties

Highly reactive corrosive to copper, copper alloys, zinc, zinc alloys, aluminum, and galvanized surfaces(3)

Compatible with

Shipped in steel tank cars, trucks, cylinders(3).

ICC Classification Coast Guard Classification

Comments colorless gas or liquid, strong ammoniacal odor(1).

References (1) 5756
(2) 1570
(3) 3281

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

EPA Name Monoethanolamine (173,279)

Other Name 2-aminoethanol

Common Names 2-aminoethanol, ethanolamine, β-aminoethyl alcohol, 2-hydroxyethylamine, β-hydroxyethylamine, ethylolamine, colamin.

Structural Formula

$NH_2CH_2CH_2OH$

Molecular Wt. [illegible] Freezing Pt. 10.5 C(1) Boiling Pt. 170.5 C(1)

Density (condensed) [illegible] @ 20/4(1) Density (gas/air) 2.11(1) @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible](1) @ @

Flash Point [illegible](1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water miscible(2) Hot water Ethanol miscible(2)

Others miscible with methanol, acetone(2)

Acid, Base Properties strong base, K (25)C = $3.39 \times 10^{-10}$, pH 25% Aq.soln: 12.1, 1N Aq. soln. [illegible](2)

Highly Reactive with

Compatible with

Shipped in ordinary steel containers(3)

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

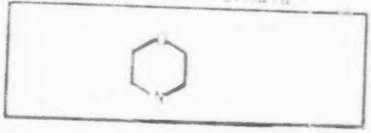
HAZARDOUS WASTES PROPERTIES
WORKSHEET

[illegible] Name Morpholine (281)

[illegible] Name

Common Names tetrahydro-1,4-oxazine
tetrahydro-2H-1,4-oxazine
diethylene oximide

Structural Formula



Molecular Wt. [illegible] Melting Pt. -4.9 C(1) Boiling Pt. 128 C(1)

Density (condensed) [illegible] @ [illegible] (1) Density (gas) [illegible] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible] @ [illegible] @

Flash Point [illegible] Autoignition Temp. 590 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water [illegible] Hot water Ethanol miscible(2)

Others: soluble in acetone, benzene, ether, methanol, ethylene glycol, oils(2)

Acid, Base Properties strong base

Highly Reactive with

Compatible with

Shipped in

ICC Classification None Coast Guard Classification

Comments steam volatile, [illegible] $H_2O$ azeotrope

References (1) 1570
(2) 149
(3) 766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name n-Propylamine (339)

IUPAC Name 1-aminopropane

Common Names

Structural Formula

$CH_3CH_2CH_2NH_2$

Molecular wt. 59 Melting Pt. -83 C(1) Boiling Pt. 47.8 C(1)

Density (Condensed) [illegible] @ 20 C Density (gas) @

Vapor Pressure (recommended 55 and 20 C)

[illegible] @ [illegible] @ @

Flash Point Autoignition Temp 604 F(2)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower 2.0% Upper 10.4%(2)

Solubility

Cold water soluble Hot water soluble( ) Ethanol very soluble( )

Others

Acid, Base Properties basic

Highly Reactive with

Compatible with

Shipped in

ICC Classification IATA: Flammable liquid, red label. Coast Guard Classification

Comments

References (1) 1570
(2) 3766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Triethanolamine (441)

IUC Name 2,2',2''-trihydroxytriethylamine

Common Names tris(hydroxyethyl)amine
trihydroxytriethylamine
2,2',2''-nitrilotriethanol

Structural Formula

$(HO-CH_2CH_2)_3N$

Molecular wt. 149.19 Melting Pt. 21.2 C(1) Boiling Pt. 360 C(1)

Density (Condensed) 1.1258 @ 20/20 C(1) Density (gas) 5.14(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 205 C(1) @ @

Flash Point 335 F (C.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt. %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water miscible(3 Hot Water miscible(3) Ethanol miscible(3)

Others

Acid, Base Properties basic(3)

Highly Reactive with slightly ether (1.6%), benzene (4.2%), carbon tetrachloride (0.9%), n-heptane (0.1%), ligroin, soluble chloroform, miscible acetone, methanol(3).

Compatible with

Shipped in standard iron and steel containers(4)

ICC Classification none Coast Guard Classification

Comments very hydroscopic and viscous(3)

References (1) 0766
(2) 1570
(3) 1492
(4) 2299

HAZARDOUS WASTES PROPERTIES
WORKSHEET

Chemical Name Triethylamine (442)

IUPAC Name

Common Names triethylamine

Structural Formula

$(CH_3CH_2)_3N$

Molecular Wt. 101.19 Melting Pt. -114.7 C(1) Boiling Pt. 89.3 C(1)

Density (Condensed) 0.7275 @ 20/4 C(1) Density (gas) 3.48 @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] mm @ 20 C(1) 230 mm @ 55 C(3) @

Flash Point 20 F (-7 C)(2) Autoignition Temp

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.2% Upper 8.0%(2)

Solubility

Cold water soluble less than 19 C(1) Hot water slightly soluble(3) above 19 C Ethanol miscible(3)

Others acetone, benzene, ether(3)

Acid, Base Properties basic

Highly Reactive with

Compatible with

Shipped in

ICC Classification IATA: Flammable, red label Coast Guard Classification

Comments

References (1) 1570
(2) 0766
(3) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Triethylene tetramine (444)

IUC Name

Common Names

Structural Formula

$H_2NCH_2(CH_2NHCH_2)_2CH_2NH_2$

Molecular wt. 146.24 Melting Pt. 12 C(1) Boiling Pt. 266.7 C(1)

Density (condensed) 0.982 @ 20 (2) Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 157 C(1) <0.01 mm @ 20 C(2) @

Flash Point [illegible](2) Autoignition Temp. 640 F(2)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Hot water soluble(1) Ethanol soluble(1)

Others acetone(1)

Acid, Base Properties basic

Highly Reactive with

Compatible with

Shipped in

ICC Classification MCA warning label Coast Guard Classification

Comments

References (1) 3570

(2) 3766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. No. Name Trimethylamine (445)

IUC Name

Common Names

Structural Formula

$(CH_3)_3N$

Molecular wt. 59.11 Melting Pt. -117.2 C(1) Boiling Pt. 2.87 C(1)

Density (condensed) 0.6709 @ 0/4 C(1) Density (gas) 2.0(3) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp. 374 C(3)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %)(3) Lower 2.0% Upper 11.6%(3)

Solubility

Cold water miscible(1) Hot water Ethanol soluble(1)

Others ether, benzene, toluene, chloroform(1)

Acid, Base Properties strong base, $K_b = 7.4 \times 10^{-5}$ (25 C)(2)

Highly Reactive with oxidizing material(3)

Compatible with

Shipped in

ICC Classification Flammable, red label IATA, flammable gas, red label Coast Guard Classification Red label(3)

Comments

References (1) 1570

(2) 1492

(3) 0766

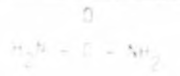
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Urea (448)

IUC Name

Common Names Carbamide, Carbonyl diamide

Structural Formula



$$H_2N-\overset{O}{\overset{\|}{C}}-NH_2$$

Molecular wt. 60.1 Melting Pt. 132.7 C[1] Boiling Pt. decomposes[1]

Density (Condensed) 1.335[1] @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Slightly dangerous when heated to decomposition.

Solubility

Cold water very soluble[2] Hot water very soluble[2] Ethanol soluble[2]

Others: almost insoluble in chloroform and ether[2], soluble methanol, glycerol[2].

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification none Coast Guard Classification

Comments no importance as an industrial hazard[1]

References (1) 0766

(2) 1492

# PROFILE REPORT ON ESTERS

Amyl Acetate (30), Butyl Acetate (72), Butyl Acrylate (73), Di-*n*-butyl Phthalate (139), Ethyl Acetate (175), Ethyl Acrylate (176), Ethyl Phthalate (194), Isobutyl Acetate (224), Isopropyl Acetate (229), Methyl Acetate (262), Methyl Acrylate (263), Methyl Formate (270), Methyl Methacrylate (273), n-Propyl Acetate (357), Vinyl Acetate (445).

## I. GENERAL

### Introduction

The esters treated in this report have all been selected as probable candidate waste stream constituents for municipal disposal. These materials are similar in that most are commodity chemicals with relatively low toxicity, well-defined and safe methods of industrial handling and common methods of disposal. The esters are, therefore, discussed as a class in this report.

### Manufacture

The most common method of ester formation is the direct reaction of a carboxylic acid with an alcohol. The addition of an acid catalyst such as p-toluenesulfonic acid, sulfuric acid or hydrogen chloride speeds the approach to equilibrium. Many procedures are used to disturb this equilibrium and force the reaction to completion. These involve the removal of one or more reactants or products by simple or complex distillation, azeotrope formation,and removal of water by desiccation or chemical means.

Acrylic acid and the acrylates have a tendency to polymerize in the presence of acid and for this reason, most acrylates are made by other methods. The most widely used method is the reaction of carbon monoxide, acetylene and an alcohol in the presence of a nickel catalyst.

Vinyl acetate is produced by the reaction of acetic acid with acetylene.

## Uses[1433,1506]

Solvents and Plasticizers. The greatest uses of esters are as solvents and plasticizers. The lower esters are used in the lacquer, paint, and varnish fields, and the higher ones are used primarily as plasticizers.

Resins, Plastics and Coatings. Many polymeric materials in commercial use are based on esters. These include vinyl polymers made from such unsaturated esters as the acrylates, methacrylates, vinyl acetate and their homologs; alkyd resins which are essentially crosslinked polyesters prepared from polyhydric alcohols and dibasic acids, and the polyester resins and plastics.

Lubricants. Esters, in the form of natural fats, oils and waxes have been used as lubricants since ancient times. Animal and vegetable fats and oils have largely been supplanted by petroleum hydrocarbons and multi-viscosity systems based on the acrylates and isobutylene.

Perfumes, Flavors, Cosmetics and Soap. Compared with the volume of esters used in solvents and plasticizers, the tonnage of esters used in improving odors and flavors is small, but nevertheless important economically and aesthetically.

Medicinals. Although the ester group itself is relatively inert physiologically, esters are used widely in pharmaceuticals. In general, esterification of a physiologically active alcohol or phenol with an aliphatic acid detoxifies it by decreasing the concentration of active compound present. The active compound is released gradually in the body by hydrolysis of the ester. An example of detoxification is acetylation of salicylic acid to give acetylsalicylic acid, the sodium salt of which is the common analgesic, aspirin.

## 2. TOXICOLOGY[0766]

The esters treated in this report are relatively non-toxic. They act mainly as irritants to the mucous membranes, particularly the eyes, gums and respiratory passages. Prolonged contact or repeated exposure can cause conjunctival irritation and corneal clouding. They are also mildly narcotic, the principal symptoms being headache, fatigue, drowsiness and oppression in the chest. Death is extremely rare. The methyl esters are greater irritants than the higher homologues, while the opposite is true for the narcotic effects. The acrylates are considered to be more toxic than the acetate, formate and phthalate esters.

Chronic poisoning has not been fully investigated, but in the case of ethyl acetate, it can produce secondary anemia, leucocystosis and cloudy swelling, and fatty degeneration of the viscera.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) that have been established are:

| Substance | TLV | | MAC |
|---|---|---|---|
| | ppm | mg/M$^3$ | ppm |
| Amyl acetate | 100 | 525 | 100 |
| Butyl acetate | 150 | 710 | 200 |
| Butyl acrylate | - | - | - |
| Di-n-butyl phthalate | - | 5 | - |
| Ethyl acetate | 400 | 1400 | 400 |
| Ethyl acrylate | 25 | 100 | 25 |
| Ethyl phthalate | - | - | - |
| Isobutyl acetate | 150 | 700 | - |
| Isopropyl acetate | 250 | 950 | - |
| Methyl acetate | 200 | 610 | 200 |
| Methyl acrylate | 10 | 35 | - |
| Methyl formate | 100 | 250 | - |
| Methyl methacrylate | 100 | 410 | - |
| n-Propyl acetate | 200 | 840 | - |
| Vinyl acetate | 10 | 30 | - |

## 3. OTHER HAZARDS

Under the proper conditions such as the presence of oxygen or other polymerization initiator and heat, acrylate esters can polymerize violently.[0766,1433] Most esters are flammable.

## 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

### Handling, Storage and Transportation

The esters treated in this report are all toxic to a certain extent due to the narcotic effects of high concentrations and irritating effects of the liquids or vapors, especially in the sensitive areas of the eyes, mucous membranes and respiratory tract. Thus, they should be handled in a well-ventilated area and protective clothing and respirators are recommended where necessary. In cases of accidental contact, all contaminated clothing should be removed and the skin washed thoroughly with soap and water.

These materials are shipped under a variety of U.S. Department of Transportation, U.S. Coast Guard and International Air Transport Association (IATA) regulations. Most regulations relate to the flammability and corrosiveness of these compounds. Information on safe handling and use of these compounds can be found in standard reference sources or manufacturers' Technical Data Sheets.

### Disposal/Reuse

Manufacturers who use the esters as chemical intermediates or process solvents recycle as much material as possible. Material used in perfumes, flavors, cosmetics, soaps, lubricants and medicinals is consumed in small quantities by the public and not recoverable. A substantial amount of the esters in this group are used to produce plasticizers, resins, paint lattices, or plastics. This material is not recoverable.

Many of the various manufacturing processes result in dilute ester waste streams which have a high chemical and biological oxygen demand.[0285,1543] They can be treated on-site or discharged into the municipal sewers.

Recommended provisional limits for the compounds discussed in this report are listed below:

| Contaminant in Air | Provisional Limits ppm | Provisional Limits mg/M$^3$ | Basis for Recommendation |
|---|---|---|---|
| Amyl acetate | 1.0 | 5.3 | 0.01 TLV |
| Butyl acetate | 1.5 | 7.1 | 0.01 TLV |
| Butyl acrylate | - | 1.0 | Based on similar compounds |
| Di-n-butyl phthalate | - | 0.05 | 0.01 TLV |
| Ethyl acetate | 4.0 | 14 | 0.01 TLV |
| Ethyl acrylate | 0.25 | 1.0 | 0.01 TLV |
| Ethyl phthalate | - | 0.05 | Based on similar compounds |
| Isobutyl acetate | 1.5 | 7.0 | 0.01 TLV |
| Isopropyl acetate | 2.5 | 9.5 | 0.01 TLV |
| Methyl acetate | 2.0 | 6.1 | 0.01 TLV |
| Methyl acrylate | 0.1 | 0.35 | 0.01 TLV |
| Methyl formate | 1.0 | 2.5 | 0.01 TLV |
| Methyl methacrylate | 1.0 | 4.1 | 0.01 TLV |
| n-Propyl acetate | 2.0 | 8.4 | 0.01 TL |
| Vinyl acetate | 0.1 | 0.3 | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limits ppm (mg/l) | Basis for Recommendation |
|---|---|---|
| Amyl acetate | 26.3 | Stokinger and Woodward Method |
| Butyl acetate | 35.5 | Stokinger and Woodward Method |
| Butyl acrylate | 5.0 | Based on similar compounds |
| Di-n-butyl phthalate | 0.25 | Stokinger and Woodward Method |
| Ethyl acetate | 70.0 | Stokinger and Woodward Method |
| Ethyl acrylate | 5.0 | Stokinger and Woodward Method |
| Ethyl phthalate | 0.25 | Based on similar compounds |
| Isobutyl acetate | 35.0 | Stokinger and Woodward Method |
| Isopropyl acetate | 47.5 | Stokinger and Woodward Method |
| Methyl acetate | 30.5 | Stokinger and Woodward Method |
| Methyl acrylate | 1.8 | Stokinger and Woodward Method |

| Contaminant in Water and Soil | Provisional Limits ppm (mg/1) | Basis for Recommendation |
|---|---|---|
| Methyl formate | 12.5 | Stokinger and Woodward Method |
| Methyl methacrylate | 20.5 | Stokinger and Woodward Method |
| n-Propyl acetate | 42.0 | Stokinger and Woodward Method |
| Vinyl acetate | 1.5 | Stokinger and Woodward Method |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No. 1 - Recycling

Manufacturers that use esters as chemical intermediates or process solvents recycle as much material as possible. In addition, a certain amount of contaminated esters are eligible for reprocessing. This is the method of choice wherever possible.

### Option No. 2 - Treatment of Waste Water to Reduce Chemical and Biological Oxygen Demand

The esters treated in this report not only have a low level of toxicity but they can be biodegraded very rapidly by unacclimated activated sludges. This is due in part to the fact that after hydrolysis the component acids and alcohols are the same as or very similar to carboxylic acids present in normal sewage. Thus, the best method of disposal is via municipal sewage treatment plants, provided the rate of discharge is uniform.

### Option No. 3 - Incineration

Bulk quantities of contaminated esters that can not be reprocessed or released by controlled dilution can best be disposed of by incineration. Since this will probably be an unusual occurrence, this is best done at municipal or industrial incineration sites.

## G. APPLICABILITY TO NATIONAL DISPOSAL SITES

All of the wastes generated by the industries that produce and use the esters treated in this report can be handled by municipal and industrial disposal methods such as sewage treatment and incineration. Therefore, the esters discussed in this report are not judged to be candidate waste stream constituents requiring National Disposal Site treatment

## 7. REFERENCES

0285. Lund, H.F., ed. Industrial pollution control handbook. New York, McGraw-Hill Book Company1971.

0766. Sax, N I., Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. 22v. and suppl. New York, Interscience Publishers, 1966.

1501. Faith, W.L., D.B. Keyes, and R.L. Clark. Industrial chemicals. 3d ed. New York, John Wiley and Sons, Inc., 1965. 824 p.

1506. Oil, paint and drug reported profiles. New York, Schnell Publishing Publishing Company, Inc., 1970.

1543. Ludzack, F.J., M.B. Ettinger. *Journal Water Pollution Control Federation*, 32:1173-1200, 1960.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Amyl Acetate (30)

IUC Name n-amyl acetate

Common Names Pear oil

Structural Formula

$CH_3CO_2(CH_2)_4CH_3$

Molecular wt. 130.18 Melting Pt. -78.5 C(1) Boiling Pt. 148 C/(737mm)(1)

Density (Condensed) 0.879 @ 20/20 C(1) Density (gas) 4.5(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 77 F (c.c.)(1) Autoignition Temp. 714 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.1(1) Upper 7.5(1)

Solubility

Cold water insoluble Hot water Ethanol soluble(2)

Others: ethyl ether

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 0766
(2) 1492

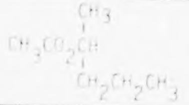
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Amyl Acetate (30)

IUC Name 2-pentyl acetate

Common Names amyl acetate

Structural Formula



$$CH_3CO_2\overset{CH_3}{\underset{|}{CH}}CH_2CH_2CH_3$$

Molecular wt. 130.1 Melting Pt. Boiling Pt. 120 C(1)

Density (Condensed) 0.862-0.866 @ 20/20 C(1) Density (gas) 4.48(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 89 F (C.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Hot water Ethanol

Others: ethyl, ether

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butyl Acetate (72)

IUC Name _n_-butyl acetate

Common Names

Structural Formula

$CH_3-CO_2(CH_2)_3CH_3$

Molecular wt. 116.16 Melting Pt. -73.5 C(1) Boiling Pt. 126 C(1)

Density (Condensed) 0.88 @ 20/20 C(1) Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

15 mm @ 25 C(1) @ @

Flash Point 72 F(1) Autoignition Temp. 790 F(1)

Flammability Limits in Air (wt. %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.7%(1) Upper 7.6%(1)

Solubility

Cold water Hot water soluble(2) Ethanol miscible(2)

Others: ether, hydrocarbons(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification Inflammable(1)

Comments

References (1) 0766
(2) 1442

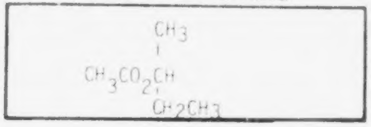
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butyl Acetate (72)

IUC Name sec-butyl acetate

Common Names

Structural Formula



$$CH_3CO_2\underset{CH_2CH_3}{\overset{CH_3}{CH}}$$

Molecular wt. 116.16 Melting Pt. Boiling Pt. 112 C(1)

Density (Condensed) 0.862-0.866 @ 20/20 C(1) Density (gas) 4.00(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 88 F (O.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt. %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.7(1) Upper

Solubility

Cold water Hot water slightly soluble(2) Ethanol soluble(2)

Others ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments n-butyl acetate and tert-butyl acetate can also be called butyl acetate and have similar properties.

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Butyl Acrylate (73)

IUC Name n-Butyl acrylate

Common Names

Structural Formula

$CH_2=CHCO_2-(CH_2)_3CH_3$

Molecular wt. 128.2 Melting Pt. -64.6 C(1) Boiling Pt. 69 C/50mm(1)

Density (condensed) .894 @ 25/25 C(1) Density (gas) 4.42(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 35.5 C(1) @ @

Flash Point [illegible](1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Hot water slightly soluble(2) Ethanol

Others: ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766
(2) 1492

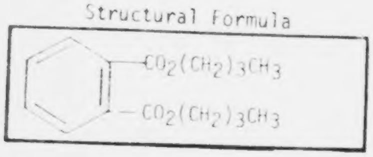
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Dibutyl Phthalate (139)

IUC Name di-n-butyl-o-phthalate

Common Names

Structural Formula



Molecular Wt. 278.3 Melting Pt. -35 C$^{(1)}$ Boiling Pt. 340 C$^{(1)}$

Density (Condensed) 1.048 @ 20/20 C$^{(1)}$ Density (gas) 9.58$^{(1)}$ @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 315 F (C.C.)$^{(1)}$ Autoignition Temp. 757 F$^{(1)}$

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethyl Acetate (175)

IUC Name ethyl acetate

Common Names

Structural Formula

$CH_3CO_2C_2H_5$

Molecular wt. 88.10 Melting Pt. -83.6 C(1) Boiling Pt. 77.15 C(1)

Density (Condensed) 0.8946 @ 25 C(1) Density (gas) 3.04(1) @

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ 27.0 C(1) @ @

Flash Point 24 F(1) Autoignition Temp. 800 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.5%(1) Upper 9%(1)

Solubility

Cold Water slightly soluble(2) Hot Water Ethanol miscible(2)

Others. acetone, chloroform, ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments Azeotropic mixture with water b.p. 70.4 C(2)

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethyl Acrylate (176)

IUC Name ethyl acrylate

Common Names ethyl propenoate

Structural Formula

$CH_2=CHCO_2C_2H_5$

Molecular wt. 100.11 Melting Pt. -72 C(1) Boiling Pt. 99.8 C(1)

Density (Condensed) 0.924 @ 20/4 C(1) Density (gas) 3.45(1) @

Vapor Pressure (recommended 55 C and 20 C)

29.3 mm @ 20 C(1) @ @

Flash Point 60 F (O.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.8%(1) Upper

Solubility

Cold Water slightly soluble Hot Water Ethanol soluble

Others: ether

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification

Comments Lacrimator(2) azeotrope with water b.p. 81 C(1)

References (1) 0766

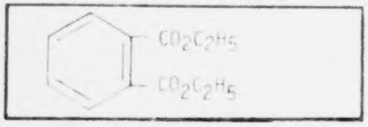
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Ethyl Phthalate (194)

IUC Name diethyl o-phthalate

Common Names

Structural Formula



Molecular wt. 222.2 Melting Pt. -40.5 C(1) Boiling Pt. 302 C(1)

Density (condensed) 1.120(1) @ Density (gas) 7.66(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 325 F (C.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water insoluble(2) Hot water Ethanol miscible(2)

Others: ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 0766

(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Isobutyl Acetate (224)

IUC Name isobutyl acetate

Common Names

Structural Formula

$CH_3CO_2CH_2CH(CH_3)_2$

Molecular wt. 116.10 Melting Pt. -98.9 C(1) Boiling Pt. 118.0 C(1)

Density (Condensed) 0.8685 @ 15 C(1) Density (gas) 4.0(1) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 12.8 C(1) @ @

Flash Point 64 F (C.C.)(1) Autoignition Temp. 793 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water soluble(2) Hot water Ethanol soluble(2)

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification

Comments

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Isopropyl Acetate (229)

IUC Name isopropyl acetate

Common Names

Structural Formula

$CH_3CO_2CH(CH_3)_2$

Molecular Wt. 102.13 Melting Pt. -73C(1) Boiling Pt. 88.4 C(1)

Density (Condensed) 0.874 @ 20/20 C(1) Density (gas) 3.52(1) @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ 17.0 C(1) @ @

Flash Point 40 F(1) Autoignition Temp. 860 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 1.8%(1) Upper 7.8%(1)

Solubility

Cold Water Hot water soluble(2) Ethanol soluble(2)

Others: ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification

Comments

References (1) 0766
(2) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Methyl Acetate (262)

IUC Name Methyl acetate

Common Names

Structural Formula

$CH_3CO_2CH_3$

Molecular wt. 74.08 Melting Pt. -98.7 C(1) Boiling Pt. 57.8 C(1)

Density (condensed) 0.9234(1) @ Density (gas) 2.55(1) @

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ 9.4 C(1) @ @

Flash Point 14 F(1) Autoignition Temp. 935 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 3.1(1) Upper 16(1)

Solubility

Cold water soluble(2) Hot water Ethanol miscible(2)

Others ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Methyl Acrylate (263)

I.U.C. Name methyl acrylate

Common Names

Structural Formula

$CH_2=CHCO_2CH_3$

Molecular wt. 86.1 Melting Pt. -75 C(1) Boiling Pt. 80 C(1)

Density (condensed) 0.943 @ 25 C(1) Density (gas) 2.97(1) @

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ 28 C(1) @ @

Flash Point 27 F (O.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.8(1) Upper 25(1)

Solubility

Cold Water soluble(2) Hot water Ethanol

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Lacrimator, azeotrope with water, b.p. 73 C(2)

References (1) 0766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Methyl Formate (270)

IUC Name methyl formate

Common Names

Structural Formula

$HCO_2CH_3$

Molecular wt. 60.05 Melting Pt. -99.8 C(1) Boiling Pt. 32.0 C(1)

Density (Condensed) 0.98149 @ 15/4 C(1) Density (gas) 2.07(1) @

Vapor Pressure (recommended 55 C and 20 C)

400 mm @ 16.0 C(1) @ @

Flash Point -2 F(1) Autoignition Temp. 853 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 5.9(1) Upper 20.(1)

Solubility

Cold water soluble(2) Hot water Ethanol miscible(2)

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification red label(1)

Comments

References (1) 766

(2) 1492

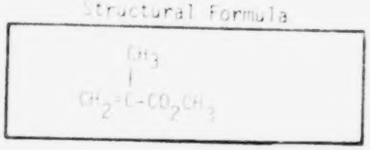
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Methyl Methacrylate (273)

IUC Name methyl 2-methylpropenoate

Common Names

Structural Formula



$$CH_2{=}\overset{\displaystyle CH_3}{\overset{|}{C}}{-}CO_2CH_3$$

Molecular wt. 100.1(1) Melting Pt. -50 C(1) Boiling Pt. 101.0 C(1)

Density (condensed) 0.936 @ 20/4 C(1) Density (gas) 3.45(1) @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ [illegible](1) @ @

Flash Point [illegible] F [illegible](1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.1(1) Upper 12.5(1)

Solubility

Cold Water Hot Water Ethanol

Others:

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label(1) Coast Guard Classification

Comments

References (1) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name n-Propyl Acetate (357)

IUC Name n-propyl acetate

Common Names

Structural Formula

$CH_3CO_2CH_2CH_2CH_3$

Molecular wt. 102.13 Melting Pt. -92.5 C[1] Boiling Pt. 101.6 C[1]

Density (Condensed) 0.887[1] @ Density (gas) 3.52[1] @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ 28.8 C[1] @ @

Flash Point 58 F[1] Autoignition Temp. 842 F[1]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.0[1] Upper 8.0[1]

Solubility

Cold water slightly soluble[2] Hot water Ethanol miscible[2]

Others ether[2]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 766

(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Vinyl Acetate (449)

IUC Name vinyl acetate

Common Names

Structural Formula

$CH_3CO_2CH=CH_2$

Molecular wt. [illegible]   Melting Pt. -100.2 C[1]   Boiling Pt. 73 C[1]

Density (condensed) [illegible] @ [illegible] C[1]   Density (gas) 3.0[1] @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible]   @   @

Flash Point [illegible]   Autoignition Temp. 800 F[1]

Flammability Limits in Air (wt %)   Lower   Upper

Explosive Limits in Air (wt. %)   Lower 2.6[1]   Upper 13.4[1]

Solubility

Cold water slightly soluble[2]   Hot Water   Ethanol miscible[2]

Others ether[1]

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable, red label[1]   Coast Guard Classification red label[1]

Comments

References (1) 0766

(2) 1492

# PROFILE REPORT

Aniline (32), 2,4-Dinitroaniline (161), n-Methylaniline (280), α-Naphthylamine (286), Phenylhydrazine Hydrochloride (328), Pyridine (364), o-Toluidine (435), Acridine (464)

## 1. GENERAL

### Introduction

The aromatic nitrogen-containing compounds treated in this report have been selected as probable candidate waste stream constituents for industrial disposal because of their comparatively low toxicity and well-defined methods for handling in an industrial context. These materials also share common methods for disposal and have therefore been grouped for discussion here.

### Manufacture

Aniline. Aniline is produced commercially by the reduction of nitro benzene either in a continuous, vapor-phase process, by a batch solution method, or by the amination of chlorobenzene.[1433] Total U.S. production of aniline for 1970 was 398,362,000 lb.[1718, 1655]

Acridine. Acridine is one of the chief components produced commercially from coal tar. It is also readily available by a synthesis route employing the ring-closure of phenylanthranilic acid to acridone followed by reduction with zinc dust.

2,4-Dinitroaniline. 2,4-dinitroaniline is prepared by ammonolysis of 2,4-dinitrochlorobenzene.[1433] U.S. production was 196,000 lb in 1970.[1718]

n-Methylaniline. Aniline reacts with methanol in the presence of a copper-alumina catalyst to give a 96 percent yield of n-methylaniline.

-Naphthylamine. -naphthylamine is prepared by a procedure developed by Bucherer (1904) consisting of heating -naphthal with aqueous ammonium sulfite under pressure. The corresponding amine is obtained in excellent purity and 89 to 95 percent yield.

-Toluidine.[1433] Toluidines are prepared by reduction of the corresponding nitrotoluenes with iron and dilute acid or by their catalytic hydrogenation.

Phenylhydrazine Hydrochloride.[1656] Aniline is converted to the diazonium salt, which in turn is reduced with a sodium sulfite to phenylhydrazine and then isolated as the hydrochloride.

Pyridine. Pyridine is a byproduct of coke production. Every ton of coal carbonized produces from 0.07 to 0.21 lb pyridine bases. The pyridine bases thus obtained consist of approximately 70 percent pyridine and 30 percent higher homologs, mainly picoline. Synthetic pyridine is produced from acetaldehyde and ammonia.[1433]

## Uses

Aniline.[1433] The two most important uses of aniline are in the manufacture of dyes and rubber chemicals. Aniline is also important in the manufacture of sulfa drugs and synthetic sweetening agents.

Acridine.[1492] Used in the manufacture of dyes and intermediates. Some dyes derived from it are used as antiseptics.

2,4-Dinitroaniline.[1433] 2,4-dinitroaniline is used in the preparation of Pigment Orange (CI 12075).

n-Methylamine.[1492] Methylamine is used in tanning and in organic synthesis for the introduction of methylamine groups.

-Naphthylamine.[1492] This material is used in the manufacture of dyes.

o-Toluidine.[1433] o-toluidine is used mainly as a dye intermediate to prepare Acid Red 24, Solvent Yellow 3, Solvent Red 26, Direct Red 62 and others.

Phenylhydrazine Hydrochloride.[1492] Phenylhydrazine hydrochloride is used to manufacture phenylhydrazine and as a pharmaceutical.

Pyridine. It is an intermediate in the manufacture of pharmaceuticals, textile water repellent agents, rubber chemicals, piperidine, bactericides and herbicides.[1433]

## Physical and Chemical Properties

The physical and chemical properties of these aromatic nitrogen-containing compounds are included in the attached worksheets.

## 2. TOXICOLOGY[0766,1492]

### Aromatic Amines

Aromatic amines are highly toxic but may be handled safely if proper precautions are observed. These materials can enter the body through the lungs, the gastrointestinal tract or skin. Long and continued exposure to even small amounts may produce tumors and cancer of the bladder.

The most important action of aniline on the body is the formation of methemoglobin, with the resulting anoxemia and depression of the central nervous system. In acute exposures, the signs of aniline poisoning are methemoglobinaemia and anoxemia. In less acute exposures which have been prolonged over some weeks or months, there is usually hemolysis of the red blood cells, followed by stimulation of the bone marrow and attempts at regeneration. The liver may be affected with production of jaundice. Long continued employment in the manufacture of aniline dyes has been associated with the development of papillomatous growths of the bladder, some of which became malignant. Aniline and certain other amino compounds, particularly benzidine and beta-naphthylamine, have been suspected of causing the condition.

-Toluidine behavior is generally comparable to that of aniline. The symptoms produced by intoxication due to -toluidine are headache, weakness, difficulty in breathing, air-hunger, psychic disturbances and marked irritation of the kidneys and bladder. Both n-methylaniline and 2,4-dinitroaniline have toxic properties similar to those of aniline.

### Acridine

Acridine is strongly irritating to the skin and mucous membranes. Upon inhalation it causes sneezing, itching or even violent burning of the skin; sometimes with inflammatory swelling. It is regarded as the effective irritant in tar and creosote or pitch, which can sensitize the skin to light.

### Pyridine

Chronic exposure to pyridine has been known to cause liver and kidney damage. It may cause central nervous system depression and irritation of the skin and respiratory tract. Large doses may produce gastrointestinal disturbance.

### Phenylhydrazine Hydrochloride

The ingestion or subcutanous injection of phenylhydrazine has been shown to cause hemolyses of the red blood cells, an effect which has been utilized in the treatment of polycythemia. Pathological changes seen in animals exposed to phenylhydrazine hydrochloride include congestion of the spleen with hyperplasia of the reticuloendothelial system, degeneration and necrosis of the liver cells with extensive pigmentation, early damage to the tubules of the kidneys with fatty changes in the critical portion, and hyperplasia of the bone marrow.

The most common effect of occupational exposure is the development of dermatitis, which in sensitized persons may be quite severe. Systemic effects include anemia and general weakness, gastrointestinal disturbances and injury to the kidneys.

### Other Hazards

In general, these materials will emit highly toxic fumes when heated to decomposition.[0766] The liquids are flammable but most can be handled with little danger of fire.[2269] Solids present only a moderate fire hazard when exposed to heat and flame.[0766]

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Storage and Transportation

All necessary precautions must be taken to guard against health and fire hazards whenever these materials are handled. Leaking containers should be removed to the outdoors or to an isolated, well-ventilated area and promptly attended to by repairing the container or transferring the contents to a new container. Protective equipment suitable to prevent workers from coming into contact with these materials should be worn during handling. Adequate respiratory protection must be supplied in areas of poor ventilation.

Storage of these materials should be in cool, dry, and well-ventilated areas, away from acute fire hazards. It may be desirable to prevent liquids from freezing by storing them in a heated building. Small quantities should be stored in tightly closed, well labeled, approved containers to avoid leakage, spillage and careless handling as a result of ignorance of the contents.

A list of hazardous materials with packing and shipping instructions is found in Code of Federal Regulations, Title 49, parts 100 to 199.[0278]

### Disposal/Reuse

Contaminated or degraded materials found to be unusable in a recycling process must be disposed of in a safe manner, defined in terms of recommended provisional limits in the environment. These recommended provisional limits are as follows:

| Contaminant in Air | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Acridine | 0.15 $mg/M^3$ | Based on similar compounds |
| Aniline | 0.05 ppm (0.19 $mg/M^3$) | 0.01 TLV |
| 2,4-Dinitroaniline | 0.06 $mg/M^3$ | Based on similar compounds |
| n-Methylaniline | 0.02 ppm (0.09 $mg/M^3$) | 0.01 TLV |
| β-Naphthylamine | 0 ppm | Carcinogen |
| Phenylhydrazine HCl | 0.05 ppm (0.22 $mg/M^3$) | 0.01 TLV |
| Pyridine | 0.05 ppm (0.15 $mg/m^3$) | 0.01 TLV |
| o-Toluidine | 0.05 ppm (0.22 $mg/M^3$) | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Acridine | 0.75 ppm (mg/l) | Based on similar compounds |
| Aniline | 0.95 ppm (mg/l) | Stokinger and Woodward Method |
| 2,4-Dinitroaniline | 0.30 ppm (mg/l) | Based on similar compounds |
| n-Methylaniline | 0.45 ppm (mg/l) | Stokinger and Woodward Method |
| β-Naphthylamine | 0 ppm (mg/l) | Carcinogen |
| Phenylhydrazine HCl | 1.10 ppm (mg/l) | Stokinger and Woodward Method |
| Pyridine | 0.75 ppm (mg/l) | Stokinger and Woodward Method |
| -Toluidine | 1.10 ppm (mg/l) | Stokinger and Woodward Method |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option 1. Recycling of Concentrated Waste

It would be advisable in all cases to first contact the manufacturer to determine if the material can be recycled. The applicability of this option depends on the type and extent of contamination or degradation the material has suffered.

### Option 2. Incineration of Concentrated and Dilute Organic Waste

In the event that it becomes necessary to dispose of a significant quantity of organic waste and purification/recycling is impractical, incineration of the materials is the recommended method of disposal. The material must be incinerated under controlled conditions whereby oxides of nitrogen are removed from the effluent gas by scrubber, catalytic and/or thermal devices.[1435]

### Option 3. Activated Sludge Treatment of Dilute Aqueous Waste

The ability of activated sludge microorganisms to oxidize aromatic organic compounds has been demonstrated.[1044] Aromatic amines are generally considered to be biodegradable.[0534] In some cases, such as aniline and -toluidine, the microorganisms must be acclimated for 24 hours before oxidation takes place.[1044] Additional research in this area is indicated for individual compounds, particularly for 2,4-dinitroaniline to assure that the subject waste is completely deactivated by biological treatment.

### Option 4. Activated Carbon Treatment of Dilute Aqueous Waste[0314]

The removal of trace organic contaminants from treated waste water by absorption on activated carbon has been successfully demonstrated. This method has proven to be particularly effective in the removal of aromatic nitrogen-containing compounds which are difficult to remove by conventional biological treatment processes.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Most of the wastes generated by the industries that produce and use the aromatic nitrogen-containing materials discussed in this report can best be handled and treated at the site of the generation by the common industrial methods discussed in Section 5. Since adequate methods are available for the disposal of these materials and since those methods are currently employed by most manufacturers, users and industrial waste disposal sites, the aromatic nitrogen-containing compounds discussed in this report are not judged to be candidate waste stream constituents for National Disposal Site treatment.

The severe hazard associated with beta-naphthylamine deserves special mention. Although the ease of disposal processing causes this material not to be recommended as a candidate for National Disposal Site treatment it must be reiterated that all steps in handling and disposal must be safeguarded to avoid release to the environment.

## 7. REFERENCES

0273. Code of Federal Regulations. Title 49 -- transportation, parts 100 to 199. (Revised as of January 1, 1972). Washington, U.S. Government Printing Office, 1972. 891 p.

0314. Jones, H. R. Environmental control in the organic and petrochemical industries. Park Ridge, New Jersey, Noyes Data Corporation 1971. 257 p.

0766. Sax. N. J. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corp., 1968. 1,251 p.

1044. Marion, C. V. and George W. Maloney. Ability of activated sludge microorganisms to oxidize aromatic organic compounds. Proceeding of the 18th Industrial Waste Conference, 1963. Engineering Bulletin of Purdue University 1963. p 297-308.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. New York, Interscience Publishers, 1966. 899 p.

1435. John Zink Company. $NO_x$ destructor. Bulletin No. $NO_x$1071m, Tulsa, John Zink Company. 1 p.

1492. The Merck index of chemicals and drugs. 7th ed. Rahway, Merck Company, Inc. 1960. 1634 p.

1655. Fieser, L. F. and M. Fieser. Organic chemistry. 3d ed. Boston, D. C. Heath and Company, 1956. 1112 p.

1656. Condon, F. E. and H. Meislich. Introduction to organic chemistry. New York, Holt, Rinehart and Winston, Inc. 1960. 841 p.

1718. United States Tariff Commission. Synthetic organic chemicals. United States production and sales, 1970. Washington, U.S. Government Printing Office, 1972. 262 p.

2269. Manufacturing Chemists' Association, Inc. Chemical safety data sheet SD-17. Properties and essential information for safe handling and use of aniline. Revised 1963, Washington, Manufacturing Chemists' Association, Inc. 14 p.

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Aniline (32)

IUC Name

Common Names Aniline, phenylamine, aminobenzene
aniline oil, aminophen

Structural Formula

$C_6H_5NH_2$

Molecular wt. 93.12 (1)    Melting Pt. -6.2 C (1)    Boiling Pt. 184.4 C (1)

Density (Condensed) 1.02 (1) @ 20/4 C    Density (gas) 3.22 (4) (to air = 1.0) @

Vapor Pressure (recommended 55 C and 20 C)

1mm @ 35 C (3)    10mm @ 70 C (3)    @

Flash Point 158 F (1)    Autoignition Temp. 617 C (4)

Flammability Limits in Air (wt %)    Lower    Upper

Explosive Limits in Air (wt %)    Lower    Upper

Solubility 3.5g/100 ml (4)    6.4g/100 ml

Cold water soluble (3)    Hot water soluble (3)    Ethanol ∞ soluble (3)

Others ∞ in benzene (3), miscible alcohol, benzene, chloroform & most other organic solvents (4)

Acid, Base Properties basic $pK_b$ = 9.3 (4)

Highly Reactive with oxidizers (4), solutions of Fe, Zn, Al

Compatible with

Shipped in Tank cars, trucks, drums, bottles

DOT Classification    Coast Guard Classification

Comments Colorless, oily liquid (1), noncorrosive (4),

Mfg. Allied Chemical Corp., Am. Cyanamid Co., E. I. du Pont de Nemours & Co., Inc.; First Chem. Corp., Mobay Chem. Corp., Rubicon Chem., Inc.; Uniroyal, Inc.

References (1) 0766    (5)

(3) 1570

(4) 2269

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name 2,4 - Dinitroaniline (161)

IUC Name

Common Names 2,4 - Dinitrophenylamine

Structural Formula

$C_6H_5N_3O_4$

Molecular wt. 183.12[(1)] Melting Pt. 187.5-188 C[(1)] Boiling Pt.

Density (Condensed) 1.615[(2)] @ 14 C[(2)] Density (gas) 6.31[(3)] @

Vapor Pressure (recommended 55 C and 20 C) (Air = 1)

@ @ @

Flash Point 435 F (c.c.)[(1)] Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Insoluble[(1)] Hot water very slightly[(1)] Ethanol 18 g/100 ml[(1)]

Others: Soluble in hot

Acid, Base Properties Neutral $pK_a$ 18.46

Highly Reactive with Can react with oxidizing materials[(3)]

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Yields toxic materials upon decomposition.

Mfg.(4): American Aniline products; American Cyanamid Co.;
Southern Dyestuff Co.

References (1) 1492 (4) 1718
(2) 1570
(3) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. W. Name Monomethylaniline (280)

IUC Name

Structural Formula

$C_7H_9N^4$

Common Names Methylphenylamine(3)
N - methylaniline(3)
LD oral rabbits 280mg/kg(4)

Molecular wt. 107.15(1) Melting Pt. -57.0 C(1) Boiling Pt. 195.7 C(1)

Density (condensed) 0.986 @ 20/4(1) Density (gas) 3.7(1) @

Vapor Pressure (recommended 55 C and 20 C)

1mm @ 36 C(1) 10mm @ 76.2 C(2) 40mm @ 106C(2)

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water insoluble(3) Hot Water Ethanol soluble(3)

Others soluble in ether(3), chloroform(3)

Acid, Base Properties

Highly Reactive with when heated to decomposition, it emits highly toxic fumes of aniline.(1)

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comment: Sources(5): American Cyanamid Co.; E. I. du Pont de Nemours & Co., Inc.

References (1) 0766 (5) 1571
(2) 1570
(3) 1492

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Naphthylamine (286)

IUC Name 2 - aminonaphthalene(3) 2-naphthylamine(3)

Common Names

Structural Formula

$C_{10}H_9N^3$

Molecular wt. 143.16(1) Melting Pt. 111.5 C(1) Boiling Pt. 306.0 C(1)

Density (condensed) 1.061 @ 98/4 C(1) Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm Hg @ 108 C(1) @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Combustible with nontoxic residue(2)

Solubility

Cold water Hot Water volatile w/steam(3) Ethanol soluble(3)

Others: soluble in ether(3)

Acid, Base Properties

Highly Reactive with very toxic chemical in any of its physical forms.(1)

Repeated absorption may result in bladder tumors.(3)

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Sources(4) Wilson Dye & Chemical Dist. Inc.; Wilson Export & Import Corp.

References (1) 0766 (4) 1571

(2) 1570

(3) 1492

# HAZARDOUS WASTES PROPERTIES
# WORKSHEET

H. M. Name Phenylhydrazine Hydrochloride (328)

ICC Name

Common Names Phenylhydrazine Hydrochloride

Structural Formula

$C_6H_5NHNH_2HCl$

Molecular Wt. 144.6[(1)] Melting Pt. 245 C[(1)] Boiling Pt.

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility[(3)]

Cold water soluble Hot water Ethanol soluble

Others

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Mfg:[(4)] Eastern Chemical Corp.

References (1) 0766
(2) 1492
(3) 1571

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Pyridine (364)

IUC Name Azine(1)

Common Names

Structural Formula

$C_5H_5N^1$

Molecular Wt. 79.10(1)

Solidif. Melting Pt -42 C(1)

Boiling Pt. 115-116 C(1)

Density (Condensed) 0.9780 @ 25/4(1)

Density (gas) 2.73(3) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm Hg @ 13.2 C(3) @ @

Flash Point 68 F (20 C)(3)

Autoignition Temp. 900 F(3)

Flammability Limits in Air (wt %) Lower Upper

Explosive Range in Air (wt. %) Lower 1.8 Upper 12.4(3)

Solubility

Cold Water Miscible(1) Hot Water Ethanol Miscible(1)

Others Miscible with ether(1), Petr. Ether(1), oils(1) and many other organic solvents(1)

Acid, Base Properties Weak base(1) pKa = 5.19(1)

Highly Reactive with when heated to decomposition, it emits highly toxic fumes of cyanides(3), can react vigorously with oxidizing materials.(3) Highly flammable(4) Highly explosive(4)

Compatible with Highly toxic(4)

Shipped in

ICC Classification Flammable liquid(3)

~~Combustible liquid~~(3) ~~Inflammable liquid~~(3)

Coast Guard Classification

Comments Sources(5) J. T. Baker Chemical Co., Corco Chemical Corp., Koppers Co., Inc., Ore & Ferro Corp., S.T. Corp. George UHE Co., Inc.,

References (1) 1492 (5) 1571

(2) 1570

(3) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name o-toluidine (435)

IUC Name 2-aminotoluene(1)

Common Names 2-methylaniline(1)

Structural Formula

$C_7H_9N$

Molecular wt. 107.16(1)

Melting Pt. α, -23.7 C(1)
β, -14.7 C

Boiling Pt. 200.23 C(1)

Density (Condensed) 0.9984(1) @ 20/4

Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

1mm @ 44 C(3)

______ @ ______

______ @ ______

Flash Point 87 C

Autoignition Temp. 900 F(3)

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility(1)

Cold Water sl. sol.(1)

Hot Water ______

Ethanol ∞

Others: Ether(∞), $CCl_4$ (∞)

Acid, Base Properties basic

Highly Reactive with Oxidizing agents(4)

Compatible with ______

Shipped in ______

ICC Classification ______

Coast Guard Classification ______

Comments Dye Manufacture(2), MAC:5 ppm in air(3), Supplier: DuPont(5)

References
(1) 1570
(2) 1492
(3) 0766
(4) 1569
(5) 1571

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Acridine (464)

IUC Name ______

Structural Formula

$C_{13}H_9N$[1]

Common Names Acridine; 2,3,5,6-dibenzopyridine(1); 10-azaanthracene[1]

Molecular wt. 179.21(2)   Melting Pt. 110 C(1)   Boiling Pt. 346C(1)

Density (Condensed) 1.1005 @19.7/4C(1)   Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 129.4 C(2)   10mm @ 184.0 C(3)   40mm @ 224.2 C(3)

Flash Point ______   Autoignition Temp. ______

Flammability Limits in Air (wt %)   Lower ______   Upper ______

Explosive Limits in Air (wt. %)   Lower ______   Upper ______

Solubility (3)

Cold water ______   Hot Water slightly soluble   Ethanol soluble

Others: ether, benzene, $CS_2$

Acid, Base Properties Weak base(1)

Highly Reactive with Volatile with steam

Compatible with ______

Shipped in ______

ICC Classification ______   Coast Guard Classification ______

Comments ______

References (1) 1492
(2) 0766
(3) 1570

PROFILE REPORT

## Benzene Sulfonic Acid (56)

### Manufacture

Commercial methods of producing benzene sulfonic acid include those based on using sulfuric acid, oleum, or sulfur trioxide as sulfonating agents. Benzene is added either as a liquid or as a vapor (in excess)--the latter makes for a better acid economy. There are also processes which use a combination of these two types of hydrocarbon feed. Procedures of fairly recent origin use sulfur trioxide dissolved in sulfur dioxide (or other solvents) as a sulfonating agent and elevated temperature and pressure to increase the reaction rate and to reduce the acid consumption. Processes can be of either the batch or continuous type, though major manufacturers in this country use continuous methods.[1433]

$$C_6H_6 + H_2SO_4 \longrightarrow C_6H_5SO_3H + H_2O$$

### Uses

The main use of benzene sulfonic acid is in the production of phenol. A secondary use is in the production of resorcinol. Small amounts are used in the production of benzenesulfonyl chloride and other derivatives which serve as starting materials in various organic syntheses. Minor amounts are used as catalysts in condensation, dehydration and esterification reactions.[1433]

### Physical and Chemical Properties

The physical and chemical properties of the compound discussed in this report are included in the attached worksheet.

**Preceding page blank**

## 2. TOXICITY[0766,1433]

Benzene sulfonic acid is a very strong acid and as a consequence, causes acute local irritation when exposed to the skin, ingested or inhaled. Further details are unknown, except that animal experiments indicate moderate systemic toxicity and high irritation.

No Threshold Limit Value (TLV) has been established, however, it has been estimated to be 5.0 mg/$M^3$ (based on similar compounds).

## 3. OTHER HAZARDS

Since benzene sulfonic acid is a very strong acid, similar in many respects to sulfuric acid, dry material or aqueous solutions should not be stored or used in containers readily attacked by acid.

## 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

### Handling, Storage and Transportation

Benzene sulfonic acid is an acute local irritant to the skin, eyes and respiratory passages. The presence of moisture enhances this effect. For that reason, it should be handled in a well-ventilated area and protective clothing and respirators are recommended where dusting is a severe problem. In case of accidental contact, all contaminated clothing should be removed instantly and the skin washed thoroughly with soap and water.[0766]

Benzene sulfonic acid should be stored in a cool, dry, well-ventilated area. Opened containers should be carefully re-sealed. Containers should be checked frequently for corrosion and stock should be rotated.[0766]

### Disposal

Dilute waste streams of benzene sulfonic acid are produced in its manufacture and when it is used as a raw material in the production of phenol. However, the benzene sulfonic acid is mixed with much higher concentrations of sulfuric acid in the manufacturing wastes and with phenolic and sodium sulfate wastes from the manufacture of phenol. These are best treated by methods discussed in the Profile Reports dealing with sulfuric acid, sodium sulfate and phenol.

The benzene sulfonic acid content of aqueous waste streams is reduced by treatment with lime which results in a precipitate of calcium benzene sulfonate. The benzene sulfonic acid content of the water is still 0.1 to 0.2 g/l which may be too high for disposal of large quantities. The remaining acid content can be reduced by biological treatment.[1543]

Recommended provisional limits for benzene sulfonic acid in the environment are as follows:

| Contaminant and Environment | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Benzene sulfonic acid in air | 0.05 mg/M$^3$ | Based on similar compounds. |
| Benzene sulfonic acid in water and soil | 0.25 ppm (mg/l) | Based on similar compounds. |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No. 1 - Treatment of Aqueous Waste Streams with Lime

The benzene sulfonic acid level of aqueous waste streams can be reduced to less than 0.5 percent by treatment with lime. This effluent can be discharged directly into the municipal sewer system provided that the total daily discharge does not overload the sewage treatment plant. If this occurs, treatment as outlined in Option No. 2 is necessary. Calcium benzene sulfonate is an intermediate in the production of benzene sulfonic acid and can be reprocessed or buried in an approved California Class I-type landfill.

### Option No. 2 - Reduction in Concentration by Biological and Chemical Degradation

In those cases where the total quantity of benzene sulfonic acid can not be handled by the local waste water treatment plant, benzene sulfonic acid can easily be degraded biologically and chemically on site by conventional waste water treatment methods. Depending on whether or not the treatment is partial or complete, the waste water can be discharged either into the sewer or the storm drain.

### Option No. 3 - Incineration

Badly contaminated bulk material that cannot be reclaimed, can be disposed of by incineration. This method of disposal will require the use of an $SO_2$ scrubber on the incineration unit.

### Option No. 4 - Landfill of Calcium Benzene Sulfonate

Disposal of benzene sulfonic acid can be accomplished by mixing it with a slurry of lime to form unsoluble calcium benzene sulfonate. The resulting solid has a small but significant solubility, making it readily mobile in underground water. Thus, landfill disposal represents a long-term threat to underground water supplies and must be considered much less acceptable than Option No. 3 (incineration). Option No. 4 is acceptable only when landfill sites are totally isolated from ground and surface water and thus meet the requirements of California Class I-type landfills.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Benzene sulfonic acid is not a candidate waste stream constituent for National Disposal Sites since it can be treated adequately at the sources of generation. Furthermore, treatment methods employed represent common industrial techniques.

## 7. REFERENCES

0766. Sax, N. I. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 3d ed. 22 v. and suppl. New York, Interscience Publishers, 1966.

1543. Ludzack, F. J., and M. B. Ettinger. Chemical structures resistant to aerobic chemical stabilization. Journal Water Pollution Control Federation, 32(11):1,173-1,200, Nov. 1960.

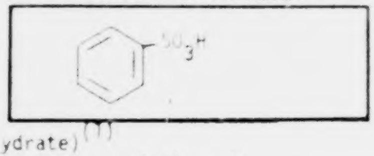
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Benzene sulfonic acid (36)

ICC Name benzene sulfonic acid

Common Names

Structural Formula



Molecular wt. 158.18 Melting Pt. 45 C (hydrate)(1) 50 C(2) Boiling Pt.

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water soluble(1) Hot Water soluble(1) Ethanol soluble(2) insoluble(1)

Others: slightly soluble benzene,(1) insoluble in carbon disulphide,(1) insoluble ether(2)

Acid, Base Properties $K(25\ C) = 2 \times 10^{-1}$, very strong acid(2)

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments used in manufacture of phenol by fusion with NaOH

References (1) 1570
(2) 1492
(3) 0766

# PROFILE REPORT

## Benzyl Chloride (58)

## 1. GENERAL

Benzyl chloride is a colorless, highly refractive liquid with a very pungent aromatic odor. Its vapors are irritating to the eyes and mucous membranes, and it is classified as a powerful lacrimator. Benzyl chloride is insoluble in cold water, but decomposes in hot water to give benzyl alcohol.[1433]

Benzyl chloride may be commercially produced by several methods. The principal method consists of chlorinating boiling toluene in the absence of light. The reaction mixture is agitated with mild alkali and distilled. It can also be produced in a continuous manner by mixing toluene and chlorine in the vapor phase.[1433]

Commercial facilities for the manufacture of benzyl chloride are operated by Hooker Chemical Company,[1815] Stauffer Chemical Company,[1571] Tenneco Chemicals Incorporated,[1571] and Velsicol Chemical Corporation.[1571]

## 2. TOXICOLOGY[1495]

Benzyl chloride is an irritant in both its liquid and vapor form. On contact with the skin it can cause redness and irritation. The warning properties of benzyl chloride are tears and coughing which generally result after exposure to concentrations of approximately 16 ppm. After severe vapor exposure, pulmonary edema may occur.

Benzyl chloride, if allowed to remain on the skin, will produce severe irritation comparable to a first degree burn. Contact with the eyes will produce severe immediate damage which may result in loss of sight. Repeated exposure to the vapor can cause tears and burning of the eyes as well as coughing.

## 3. OTHER HAZARDS[1495]

Benzyl chloride presents a moderate fire hazard [flash point is 153 F (c.c.)] and should not be handled at temperatures near its flash point unless it is in a closed system free of air or oxygen.

Unstabilized benzyl chloride readily undergoes a Friedel-Crafts type condensation reaction in the presence of copper, aluminum, iron, zinc, magnesium, tin and various other metals which act as catalysts. The heat and hydrogen chloride which are liberated, further accelerate the reaction and may result in the extremely rapid build-up of dangerous pressures in closed vessels. Stabilized benzyl chloride will also undergo the condensation reaction if the aqueous sodium carbonate stabilizing solution becomes exhausted.

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Storage, and Transportation[1495]

Benzyl chloride is classified by the Interstate Commerce Commission as a corrosive liquid. As such it must be packed in ICC specified containers when shipped by rail, water or highway and all of the ICC regulations regarding loading, handling, and labeling must be followed.[0278]

Employees handling containers of benzyl chloride should wear personal protective equipment such as chemical safety goggles, gloves and for best protection, clothing made of rubber or other impervious materials to protect the body against splashes.

Persons exposed to concentrations of benzyl chloride vapor above recommended limits should be provided with proper respiratory protection.[1495]

Stabilized benzyl chloride should never be bulk stored because of its reactive and corrosive nature. It is suggested that this material be stored in the steel drums in which it is shipped and used as soon as possible.

Anhydrous benzyl chloride may be stored for slightly longer periods than the stabilized form. Although it is usually stored in its nickel and glass shipping containers, it may be bulk stored. The material should be protected from water at all times.

## Disposal/Reuse

A definition of acceptable criteria for the disposal of benzyl chloride must also take into account acceptable criteria for the release of hydrogen chloride and hydrochloric acid to the environment, since recommended disposal methods involve some processes that reduce the benzyl chloride to these materials.

Current techniques utilize incineration and land burial. The recommended provisional limits for benzyl chloride and hydrogen chloride in the environment are as follows:

| Contaminant and Environment | Provisional Limits | Basis of Recommendation |
|---|---|---|
| Benzyl chloride in air | 0.01 ppm (0.05 mg/M$^3$) | 0.01 TLV |
| Hydrogen chloride in air | 0.05 ppm (0.07 mg/M$^3$) | 0.01 TLV |
| Hydrochloric acid in air | 0.05 ppm (0.02 mg/M$^3$) | 0.01 TLV |
| Benzyl chloride in water and soil | 0.25 ppm (mg/l) | Stokinger and Woodward Method |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

Benzyl chloride is expected to appear primarily as dilute aqueous and organic waste streams and occasionally as concentrated waste. The processing options are briefly described in the following paragraphs together with recommendations as to their adequacy.

## Concentrated Benzyl Chloride

In the event it becomes necessary to dispose of a significant quantity of concentrated benzyl chloride, two disposal options are available. The first option is to incinerate the material. It is expected that a liquid combustor followed by secondary combustion and aqueous or caustic scrubbing would be an acceptable disposal method. Primary combustion should be carried out at a minimum of 1,500 F for at least 0.5 seconds with secondary combustion at a minimum temperature of 2,200 F for at least 1.0 second. The abatement problem may be simplified by insuring against elemental chlorine formation through injection of steam or methane into the combustion process. This is an adequate means of disposal. The second option,[1495] is adding solid sodium carbonate or solid lime to the concentrated benzyl chloride and then burying the material in an approved California Class I type landfill. Concentrated benzyl chloride should not be washed down the drain or burned in open pits.

## Dilute Aqueous Waste

Benzyl chloride is insoluble in cold water, but decomposes in hot water to give benzyl alcohol.[1433] It can also be reacted with caustic to form the alcohol.[1495] It is recommended that aqueous waste containing benzyl chloride be converted to the alcohol and then be subjected to secondary treatment with activated sludge.

## Dilute Organic Waste

Dilute organic waste containing benzyl chloride can be adequately disposed of by incineration with proper scrubbing of the effluent gas to remove hydrogen chloride.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Benzyl chloride is expected to appear primarily as dilute organic waste and to a much lesser degree as dilute aqueous waste and concentrated waste. It is anticipated that facilities for handling the disposal of these wastes will be located at the manufacturing sites or at industrial disposal facilities since the disposal techniques represent common industrial technology. This material is not judged to be a candidate waste stream constituent for National Disposal Sites.

## 7. REFERENCES

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. 22v. and suppl. New York, Intersciences Publishers, 1963.

1495. Manufacturing Chemists Association. Properties and essential information for safe handling and use of benzyl chloride. Safety data sheet SD-69. Washington, 1957. 15 p.

1571. Schnell Publishing Company, Inc. 1971-72 OPD chemical buyers guide. 59th ed. New York, 1971. 1,584 p.

1815. Personal communication. J. F. Henry, J. F. Henry Chemical Company Inc., to W. P. Kendrick, TRW Systems, June 8, 1972.

1816. Personal communication. H. McClure, Velsicol Chemical Corporation, to W. P. Kendrick, TRW Systems, June 8, 1972.

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET #58

H. M. Name Benzyl Chloride (58)

IUC Name

Common Names alpha-chlorotoluene(3)

Structural Formula

$C_6H_5CH_2Cl$

Molecular wt.(1) 126.58 Melting Pt.(1) -43 C Boiling Pt.(1) 179 C

Density (Condensed) 1.1026 @ 18/4 C(1) Density (gas) 4.36(1) @ air = 1

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 22 C(2) 5 mm @ 47.8 C(2) 10 mm @ 60.8 C(2)

Flash Point 140 (cc) F(2) ( ) Autoignition Temp. 1161 F(1)
165 (o.c.) F(5)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (vol %) Lower 1.1 (in air)(2) Upper

Solubility

Cold Water 0.0033% Hot Water Hydrolyzes Ethanol

Others

Acid, Base Properties Form HCl(6)

Highly Reactive with Unless stabilized with sodium carbonate solution this compound undergoes a Friedel-Crafts type condensation w/HCl liberation.(3)

Compatible with Glass(3), nickel(3), earthenware(3)

Shipped in Glass and earthenware containers, drums, tank trucks and tank cars(3)

ICC Classification Corrosive liquid Coast Guard Classification

Comments Mfg. by: Hooker Chemical Co.(4); Stauffer Chemical Co.(5); Tenneco Chemicals Incorporated(5); and Velsicol Chemical Corp(5).

References (1) 766 (4) 1815
(2) 1433 (5) 1571
(3) 1495 (6) 1816

# PROFILE REPORT

## Butyl Phenol (78), Carbolic Acids (Phenol) (97,327), Cresol (Cresylic Acid) (124,125), Ethyl Phenol (196), Nonyl Phenol (314), Xylenol (452), Diethylstibestrol (492)

## 1. GENERAL

### Introduction

The materials treated in this report belong to the class of organic chemicals called phenols. They are distinguished by the presence of at least one hydroxyl (-OH) group, attached directly to a benzene ring. They have been grouped for discussion because of the similarities in their chemical behavior and in the applicable methods for their disposal.

### Manufacture and Use

Several of these phenolic materials comprise mixtures of isomeric compounds obtained from natural sources. For example, cresol, synonymous with cresylic acid, is a mixture of the three isomeric, monomethyl phenols obtained by the distillation of coal tar.[1492] It has an unpleasant phenolic odor and may range in color from almost colorless to dark brown, depending on age, exposure to light and original purity. Cresol is used as an intermediate in the manufacture of synthetic resins and as a local antiseptic and disinfectant.[1492]

The six xylenol isomers are also derived from coal tar by distillation and are sometimes constituents of "cresylic acid." They are used in the preparation of disinfectants and synthetic resins.

Butyl, ethyl and nonyl phenol are manufactured by alkylation of phenol with the appropriate olefin in the presence of an acid catalyst. These sterically hindered phenols are used as antioxidants and as intermediates in the manufacture of antioxidants and synthetic resins.[1433]

Phenol, at one time obtained principally from natural sources, is now prepared by a number of synthetic processes. The major portion of the phenol manufactured in this country is produced by the cumene peroxidation process and by alkaline hydrolysis of chlorobenzene. The preparation of phenolic resins consumes 50 percent of the phenol used. The rest of the production is employed in the synthesis of monomers for other resins (e.g., caprolactam, bisphenol-A and adipic acid) and of other commodities.[1506]

There are a number of possible synthetic routes to diethylstilbestrol using a variety of starting materials. It is used in estrogenic hormone therapy in humans, as an aid to increase weight gain in cattle, sheep and pigs, and as a caponization agent for poultry.[1492]

## Physical and Chemical Properties

The physical and chemical properties of the compounds discussed in this report are included in the attached worksheets.

## 2. TOXICOLOGY[0766,1492,2351]

All of the phenolic compounds discussed in this report, with the exception of diethylstilbestrol, have toxicological effects which are similar to those of phenol itself. The principal effect is on the central nervous system, manifested by headache, dizziness and muscular weakness followed, in acute cases, by loss of consciousness, collapse and death. Solid and liquid phenols have a corrosive effect on body tissues and fatal doses are readily absorbed through the skin. The severity of the toxicity and corrosiveness of the substituted phenols varies with the nature of the substitution, but it is generally less extreme than that of the unsubstituted material.

Diethylstilbestrol is less corrosive to body tissues than the other materials treated in this report. When employed in hormone therapy it has shown such side effects as gastrointestinal upset, dizziness, menstrual disturbances and headache. Its use has been associated with cell damage and is therefore contraindicated during pregnacy and lactation. There has been a great deal of concern recently with birth defects possibly caused by ingestion of meat containing trace amounts of diethylstilbestrol used to fatten cattle. This possibility is now under intensive investigation and the future use of diethylstilbestrol as a feed additive is in question.

## 3. OTHER HAZARDS[0766]

All of these phenols are considered slight fire hazards when exposed to heat or flame. However,they must be considered as moderately dangerous because of the toxic fumes emitted when they are heated to decomposition.

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Stroage and Transportation

The most important considerations with regard to the handling, storage and transportation of these materials are provisions for adequate ventilation in work areas and stringent fire prevention procedures. Personnel handling these phenols must be supplied with protective clothing to prevent skin and eye contact.[2351]

### Disposal/Reuse

Material which is contaminated in such a manner as to preclude its processing for reuse may be disposed of by any process whose environmental impact is less than the provisional limits given below:

| Contaminant in Air | Provisional Limit ppm | Provisional Limit mg/M$^3$ | Basis for Recommendation |
|---|---|---|---|
| Phenol (carbolic acid) | 0.05 | 0.19 | 0.01 TLV |
| Cresol (cresylic acid) | 0.05 | 0.19 | 0.01 TLV |
| Ethyl Phenol | - | 0.19 | Based on similar compounds |

| Contaminant in Air | Provisional Limit ppm | mg/M$^3$ | Basis for Recommendation |
|---|---|---|---|
| Butyl Phenol | - | 0.19 | Based on similar compounds |
| Nonyl Phenol | - | 0.19 | Based on similar compounds |
| Diethylstilbestrol | - | 0.19 | Based on similar compounds |
| Xylenol | - | 0.19 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Phenol (carbolic acid) | 0.001 | Drinking Water Standards |
| Cresol (cresylic acid) | 0.001 | Drinking Water Standards |
| Ethyl Phenol | 0.001 | Based on similar compounds |
| Butyl Phenol | 0.001 | Based on similar compounds |
| Nonyl Phenol | 0.001 | Based on similar compounds |
| Diethylstilbestrol | 0.001 | Based on similar compounds |
| Xylenol | 0.001 | Based on similar compounds |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No. 1 - Biological Treatment of Aqueous Wastes

Phenolic compounds, with few exceptions, have been found to show very little resistance to acclimated microorganisms.[1543] The use of biological treatment processes, particularly activated sludge, is a recommended method for the disposal of aqueous wastes containing these materials and of concentrated phenolic wastes after they have been extensively diluted with water.

### Option No. 2 - Incineration

Controlled incineration of phenolic wastes is a currently used and is an acceptable method for the disposal of organic and aqueous waste containing these materials.[0285]

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Wastes containing the materials discussed in this report may be properly disposed of by incineration or biological treatment, provided that no other contaminants are present which preclude the use of those methods. Since the equipment necessary for the implementation of these processes are commonly available at municipal and industrial facilities, these materials are not judged to be candidate waste stream constituents requiring National Disposal Site treatment.

## 7. REFERENCES

0285 Lund, H.F., ed. Industrial pollution control handbook. New York, McGraw-Hill Book Company, 1971. 843 p.

0766 Sax, I.R., Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433 Kirk-Othmer encyclopedia of chemical technology. 3d ed. 22 V. New York, Interscience Publishers, 1966.

1492 The Merck index of chemicals and drugs. 7th ed. Rahway, New Jersey, Merck Company, Inc., 1960. 1,634 p.

1506 Oil, paint and drug reported profiles. New York, Schnell Publishing Company, Inc., 1970.

1543 Ludzack, F.J., M.B. Ettinger. Chemical structures resistant to aerobic chemical stabilization. Journal Water Pollution Control Federation, 32(11):1173-1200, Nov. 1960.

1570 Weast, R.C., ed. Handbook of chemistry and physics. 48th ed. Cleveland, Ohio, Chemical Rubber Company, 1969. 2,100 p.

1571 Schnell Publishing Company. 1971-72 OPD chemical buyers guide. 1971. 1584 p.

2351 Baskin, A.D., ed. Handling guide for potentially hazardous commodities. Chicago, Railway Systems and Management Association, 1972.

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butyl Phenol (78)

IUC Name 4-t-butylphenol

Common Names p-t-butylphenol, butylphen

Structural Formula

$C_4H_9C_6H_4OH$

Molecular wt. 150.21[(1)] Melting Pt. 98 C[(1)] Boiling Pt. 237 C[(1)]

Density (Condensed) 0.9081 @ 114/4 C Density (gas) 5.1[(2)] @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 70 C[(2)] @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower Upper

Solubility

Cold water insoluble[(1)] Hot water Ethanol soluble

Others ether

Acid, Base Properties weak acid

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments volatile with steam,[(2)]. Sources[(3)] EPS Chemical Co., Fallek Products Co., Productol Chemical Co.

References (1) 1492

(2) 0766

(3) 1571

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethyl Phenol (196)

IUC Name 1-ethyl-2-hydroxybenzene

Common Names 2-ethylphenol, o-ethylphenol, phlorol

Structural Formula

$C_2H_5C_6H_4OH$

Molecular wt. 122.17 Melting Pt. <-18 C Boiling Pt. 207 C(1)

Density (Condensed) 1.0371 (1) @ 0 C Density (gas) ____ @ ____

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 84.7 C ____ @ ____ ____ @ ____

Flash Point ____ Autoignition Temp ____

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold water slightly soluble(1) Hot water ____ Ethanol soluble

Others: ether, acetone, benzene

Acid, Base Properties weak acid

Highly Reactive with ____

Compatible with ____

Shipped in ____

ICC Classification ____ Coast Guard Classification ____

Comments ____

References (1) 1570

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Nonyl Phenol (314)

IUC Name

Common Names p-nonyl phenol

Structural Formula

$C_9H_{19}C_6H_4OH$

Molecular wt. 220.34 Melting Pt. Boiling Pt. 290-301 C(1)

Density (Condensed) 0.949 @ 20/4 C Density (gas) 7.59(1) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 300 F (T.O.C.)(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water very slight(2) Hot water Ethanol soluble

Others: benzene, chlorinated solvents, heptane

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Sources(3): Fallek Chemical Corp., ICI American Inc., Jefferson Chemical Co., Productol Chemical Co., Rohm and Hass Co., Stepan Chemical Co.,

References (1) 0766

(2) 1492

(3) 1571

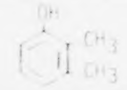
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Xylenol (452)

IUC Name 2,3-dimethylphenol

Common Names vic-o-xylenol

Structural Formula



Molecular wt. 122.16 Melting Pt. 75 C(1) Boiling Pt. 218 C(1)

Density (condensed) ______ @ ______ Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ ______ ______ @ ______

Flash Point ______ Autoignition Temp. ______

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility

Cold water slightly soluble(1) Hot water ______ Ethanol soluble

Others chloroform, ether, benzene

Acid, Base Properties ______

Highly Reactive with ______

Compatible with ______

Shipped in ______

DOT Classification ______ Coast Guard Classification ______

Comments ______

References (1) 1442

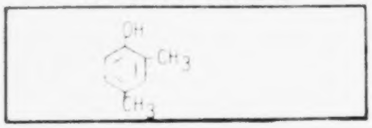
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Xylenol (452)

IUC Name 2,4-dimethylphenol

Common Names as-m-xylenol

Structural Formula



Molecular wt. 122.16 Melting Pt. 25.4-26 C(1) Boiling Pt. 211.5 C(1)

Density (Condensed) ______ @ ______ Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ ______ ______ @ ______

Flash Point ______ Autoignition Temp. ______

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility

Cold water slightly soluble(2) Hot water ______ Ethanol soluble

Others chloroform, ether, benzene

Acid, Base Properties ______

Highly Reactive with ______

Compatible with ______

Shipped in ______

ICC Classification ______ Coast Guard Classification ______

Comments Sources(2): Aceto Chemical Co., Profuctol Chemical Co.

References (1) 1492

(2) 1571

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Xylenol (452)

IUC Name 2,5-dimethylphenol

Common Names p-xylenol

Structural Formula

Molecular Wt. 122.16 Melting Pt. 74.5 C[(1)] Boiling Pt. 211.5 C[(1)]

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt. %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water slightly soluble[(1)] Hot water Ethanol soluble

Others: chloroform, ether, benzene

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Sources[(2)] M. W. Hardy & Co., Productol Chemical Co.

References (1) 1492
(2) 1571

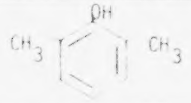
HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Xylenol (452)

IUC Name 2,6-dimethylphenol

Common Names vic-m-xylenol

Structural Formula



Molecular wt. 122.16 Melting Pt. 49 C(1) Boiling Pt. 203 C(1)

Density (Condensed) ____ @ ____ Density (gas) ____ @ ____

Vapor Pressure (recommended 55 C and 20 C)

____ @ ____ ____ @ ____ ____ @ ____

Flash Point ____ Autoignition Temp. ____

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold water slightly soluble(1) Hot Water ____ Ethanol soluble

Others: chloroform, ether, benzene

Acid, Base Properties ____

Highly Reactive with ____

Compatible with ____

Shipped in ____

ICC Classification ____ Coast Guard Classification ____

Comments Source(2): M.W. Hardy & Co.

References (1) 1492

(2) 1571

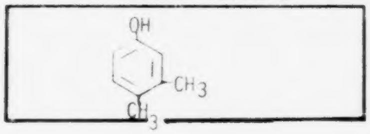
# HAZARDOUS WASTES PROPERTIES
# WORKSHEET

H. M. Name Xylenol (452)

IUC Name 3,4-dimethylphenol

Common Names as-o-xylenol

Structural Formula



Molecular wt. 122.16 Melting Pt. 62.5 C(1) Boiling Pt. 225 C(1)

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water slightly soluble(1) Hot Water Ethanol soluble

Others: chloroform, ether, benzene

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Sources(2): M.W. Hardy & Co., Koppers Co., Productol Chemical Co.

References (1) 1492

(2) 1571

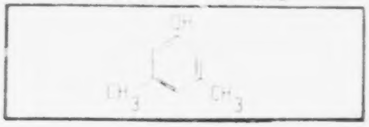
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Xylenol (452)

IUC Name 3,5-dimethylphenol

Common Names sym-m-xylenol

Structural Formula



Molecular wt. 122.16 Melting Pt. 64 C(1) Boiling Pt. 219.5 C(1)

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water slightly soluble(1) Hot Water Ethanol soluble

Others: chloroform, ether, benzene

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments: Sources(2): M.W. Hardy & Co., Koppers Co.

References (1) 1492

(2) 1571

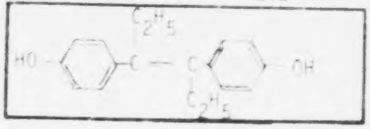
## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Diethylstilbestrol (492)

IUC Name 4,4'-dihydroxy-α,α'-diethylstilbene

Common Names stilbestrol

Structural Formula



Molecular wt. 268.34 Melting Pt. 169-172 C(1) Boiling Pt.

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water almost insoluble(1) Hot water Ethanol soluble

Others ether, chloroform, fatty oils, dilute hydroxides(1)

Acid, Base Properties neutral(1)

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Sources(2): Abbott Laboratories, American Roland Corp., Chemetron Corp., Desmo Chemical Corp.

References (1) 1492
(2) 1571

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Cresol, Cresylic Acid (124,125)

IUC Name

Common Names Cresylol, tricresol

Structural Formula

$CH_3C_6H_4OH$

Molecular wt. 108.1 Melting Pt. 10.9-35.5 C(1) Boiling Pt. 191-203 C(1)

Density (Condensed) 1.030-1.038 @ 25/25 C(1) Density (gas) 3.72(1) @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 38-53 C(1) @ @

Flash Point 110 F(1) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt %) Lower Upper 1.35 @ 300 F

Solubility

Cold water 50 parts(2) Hot water Ethanol miscible

Others: benzene, ether, glycerol, petroleum, ether, alkali.(2)

Acid, Base Properties acid

Highly Reactive with oxidizing agents(1)

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Sources(3): Concord Chemical Co., Crowley Tar Products, Co., Fallek Chemical Corp., Koppers Co., Pitt-Concol Chemical Co., Productol Chemical Co., Tar Residuals, USS Chemicals.

References (1) 0766
(2) 1492
(3) 1571

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Carbolic Acid, Phenol (97,327)

IUC Name phenol

Common Names phenic acid, phenylic acid

Structural Formula

$C_6H_5OH$

Molecular wt. 94.11 Melting Pt. 40.6 C[(1)] Boiling Pt. 181.9 C[(1)]

Density (condensed) 1.072[(1)] @ Density (gas) 3.24[(1)] @

Vapor Pressure (recommended 55 C and 20 C)

1 mm @ 40.1 C[(1)] @ @

Flash Point 175 F (O.C.)[(1)] Autoignition Temp. 1319 F[(1)]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water 1 g in 15 ml[(2)] Hot water Ethanol soluble

Others chloroform, ether, glycerol, carbon disulfide[(2)]

Acid, Base Properties acid[(2)]

Highly Reactive with oxidizing materials[(1)]

Compatible with

Shipped in

ICC Classification Poison B[(1)] Coast Guard Classification Poison B[(1)]

Comments Sources[(3)] Allied Chemical Corp., Browning Chemical Corp., Dow Chemical Co., and many others.

References (1) 0766
(2) 1492
(3) 3571

# PROFILE REPORT

## Butyl Mercaptan (77), Ethyl Mercaptan (192), Methyl Mercaptan (272)

## 1. GENERAL

Mercaptans (thiols) are sulfur-containing organic compounds analogous in structure to alcohols and phenols with the hydroxyl oxygen replaced by a sulfur atom (-SH). Their physical and chemical properties, however, are often strikingly different than those of their oxygen analogs.[1656] The volatile mercaptans have an extremely disagreeable odor; e.g., as little as one volume of ethyl mercaptan in 60 billion volumes of air can be detected by the nose. The obnoxious odor of mercaptans decreases with increasing molecular weight. Like hydrogen sulfide, the lower molecular weight mercaptans are toxic.[1316]

The isomeric butyl mercaptans (normal, secondary and tertiary) are mobile liquids having a very disagreeable heavy skunk-like odor.[1492] They are classified as moderately toxic as well as moderate fire hazards. All emit highly toxic fumes when heated to decomposition or on contact with acid or acid fumes.[0766] Ethyl mercaptan is a colorless liquid having a penetrating leek-like odor.[1492] It is considered less toxic than butyl mercaptan but is still a moderate toxic hazard.[0766] Methyl mercaptan is a flammable gas having an odor of rotten cabbage.[1492] It is less toxic than butyl but more so than ethyl mercaptan.

The major industrial processes for the manufacture of alkanethiols (aliphatic mercaptans) employ the reaction of hydrogen sulfide with olefins or with alcohols. Reaction of hydrogen sulfide with a tertiary olefin in the presence of an acidic catalyst results in a tertiary alkanethiol.[1433]

Ethyl and butyl mercaptan are used as intermediates in the manufacture of various agricultural chemicals. Methyl mercaptan is used in the first step of a commercial synthesis of methionine, an amino acid feed supplement.[1433]

Commercial facilities for the manufacture of n-butyl and ethyl mercaptan are operated by Pennwalt Corporation and Phillips Petroleum Company. Phillips Petroleum Company also manufactures sec- and tert- butyl mercaptan. Methyl mercaptan is manufactured by Air Products & Chemical Inc. and Pennwalt Corporation.[1571] Physical/chemical properties are summarized in the attached worksheets.

## 2. TOXICOLOGY

### Butyl Mercaptan

The butyl mercaptans are moderately toxic when ingested, inhaled or come in contact with the skin. The maximum allowable concentration (MAC) for n-butyl mercaptan is 10 ppm for 8-hr exposure.[0766] The compound is only slightly toxic but its revolting odor may cause nausea. It may be narcotic in high concentrations.[1492]

### Ethyl Mercaptan

Ethyl mercaptan is moderately toxic when ingested, inhaled or comes in contact with the skin. The MAC for ethyl mercaptan is 250 ppm for an 8-hr exposure.[0766] Headache, nausea and irritability are signs of ethyl mercaptan poisoning.

### Methyl Mercaptan

Methyl mercaptan is moderately toxic when ingested, inhaled or comes in contact with the skin. The MAC for methyl mercaptan is 50 ppm for an 8-hr exposure.[0766] It is somewhat similar to but less severe than the toxic effects of hydrogen sulfide. It is recommended that the Manufacturing

Chemists Association (MCA) Bulletin on hydrogen sulfide, SD36, be read before handling this material.[1696]

## 3. HEALTH AND SAFETY FACTORS[0766,1492]

All the subject mercaptans are flammable, with ethyl mercaptan having known explosive limits. They are dangerous when heated to decomposition due to the emission of highly toxic fumes. These materials have a revolting odor which may cause nausea and in addition, the vapors may be narcotic in high concentrations.

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Storage, and Transportation

Steel, stainless steel and copper-free steel alloys are the preferred materials of construction for mercaptan service. In particular, stainless steel should be used for any vessel or line which is to be open and exposed to air frequently.

Aluminum is also suitable for mercaptan use provided the pressure rating of aluminum equipment or piping is sufficient to meet pressure requirements of the application.[1697]

Venting of storage tanks in order to reduce pressure should be to a scrubber to remove the mercaptan. Either an activated-carbon scrubber[1696] or caustic scrubber[1684] is recommended. It is suggested that only hermetically sealed pumps be used.[1697]

Plastic gloves and chemical goggles should be worn to protect the skin and eyes when handling mercaptans. A self-contained breather type mask is recommended for protection when working in areas of high vapor concentration or for prolonged exposure to lower concentrations of vapor.[1697]

## Disposal/Reuse

A definition of acceptable criteria for the disposal of mercaptans must also take into account acceptable criteria for the release of sulfur dioxide and hydrogen sulfide to the environment since current practice in mercaptan disposal usually involves processing the mercaptans to hydrogen sulfide and/or sulfur dioxide. Provisional limits for mercaptans, $H_2S$ and $SO_2$ in effluent streams released to the environment from mercaptan waste disposal processes are as follows:

| Contaminant in Air | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Butyl mercaptan | 0.005 ppm (0.01 mg/$M^3$) | 0.01 TLV |
| Ethyl mercaptan | 0.005 ppm (0.01 mg/$M^3$) | 0.01 TLV |
| Methyl mercaptan | 0.005 ppm (0.01 mg/$M^3$) | 0.01 TLV |
| $H_2S$ released to the air outside the boundaries of the processing plant. | 0.1 ppm | Below the concentration where an odor can be detected[0743] |
| $H_2S$ released to the air inside the boundaries of the processing plant. | 10 ppm | Threshold limit for repeated 8-hr exposure[0743] |
| $SO_2$ released to air from tall processing stack. | 200 lb/hr of $SO_2$ effluent at a maximum stack concentration of 500 ppm | Los Angeles Air Pollution Control District Rule 53.2 |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Butyl mercaptan | 0.05 ppm(mg/1)/24 hrs | Stokinger and Woodward Method |
| Ethyl mercaptan | 0.05 ppm(mg/1)/24 hrs | Stokinger and Woodward Method |
| Methyl mercaptan | 0.075 ppm(mg/1)/24 hrs | Stokinger and Woodward Method |
| $H_2S$ released to public water sources. | 0.1 mg/liter | To avoid fish kills and water taste[0091] |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

Mercaptans are expected to appear primarily as organic waste streams, some as aqueous waste and rarely as concentrated waste. The processing options are briefly described in the following paragraphs together with recommendations as to their adequacy.

### Concentrated Mercaptans

Concentrated mercaptan wastes appear in two forms; gaseous and liquid. All the subject mercaptans have gaseous waste to some degree. Liquid waste is associated with the ethyl and butyl mercaptans.

Gaseous Waste. It is recommended[1697] in the handling and storage of mercaptans that incineration be used to burn vapors emitted during pressure reduction of storage tanks. This method is adequate provided some means is used to remove the sulfur components in the effluent gas (see Profile Report on Hydrogen Sulfide [221]). For low volume or intermittant discharge such as tank car venting, an activated-carbon scrubber may be used.[1696]

Liquid Waste. Recycling of the concentrated mercaptans is practical in some cases depending on the contaminating materials, but in most cases the waste is disposed of by incineration. In the current incineration disposal process, a Claus sulfur recovery unit is used to recycle the sulfur and reduce hydrogen sulfide and sulfur dioxide emissions to meet state and local regulations.[1680] Incineration followed by effective scrubbing of the effluent gas is an acceptable means of disposing of mercaptans.

### Dilute Mercaptan Waste

Dilute mercaptan waste can appear as organic or aqueous waste. Dilute organic wastes are incinerated and the effluent gas scrubbed with a caustic solution. Dilute aqueous waste is thermally oxidized (incinerated) by spraying the aqueous solution into an incinerator at a temperature of 2000 F then scrubbing the effluent gas with caustic solution.[1684] These are adequate methods for the disposal of dilute mercaptan waste.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Mercaptan wastes are expected to appear as concentrated liquid and gaseous wastes and as dilute organic and aqueous waste. It is anticipated that systems as described in Section 5 to handle mercaptan wastes will be located at the source of the waste generation. Adequate methods are available for the disposal of these materials and are currently in use, therefore, they are not judged to be candidate waste stream constituents for National Disposal Sites.

## 7. REFERENCES

0091. Cost of clean water. In Industrial waste profiles, v. 3. No. 5. petroleum refining. Federal Water Pollution Control Administration. Washington. Publication No. IWP-5. 1968. 199 p.

0743. Stauffer Chemical Company. Safe handling of liquid hydrogen sulfides. Product Report. Los Angeles. 24 p.

0766. Sax, N. I. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Company, 1968. 1,251 p.

1316. Moller, C. R. Chemistry of organic compounds. 2d ed. Philadelphia, W. B. Saunders Company, 1957. 978 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 2d ed. 22 v. and suppl. New York, Wiley-Interscience Publishers, 1963-1971.

1492. Merck and Company. The Merck index of chemicals and drugs. Rahway, New Jersey, 1960. 1,643 p.

1571. 1971-72 OPD chemical buyers guide. New York, Schnell Publishing Company, 1971. 1,584 p.

1656. Condon, L. E., and H. Meislick. Introduction to organic chemistry. New York, Holt, Rinehart and Winston Inc., 1960. 841 p.

1680. Personal communication. R. Laitner, Pennwalt Corporation, to W. Kendrick, TRW Systems, May 5, 1972.

1684. Personal communication. D. Treet, Rollins Purle, to W. Kendrick, TRW Systems, May 8, 1972.

1696. Pennsalt Chemicals Corporation. Handling and properites of methyl mercaptan. S-189-A. Philadelphia, 1968. 12 p.

1697. Pennwalt Corporation. Pennwalt Mercaptans, storage, and handling. 19102, Philadelphia. 6 p.

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Ethyl Mercaptan (192)

IUC Name Ethanethiol

Structural Formula

$CH_3CH_2SH$

Common Names Thioethyl alcohol(1), Ethyl Hydrosulfide(3)
Ethyl Sulfhydrate(4)
MAC: (ACGIH) Tentative; 250 ppm in air(3)

Molecular wt. 62.13 Melting Pt. -121 to -140 C(2) Boiling Pt. 34 - 37 C(1)

Density (condensed) 0.83907 @ 20 C/4 C(3) Density (gas) 2.14(3) @

Vapor Pressure (recommended 55 C and 20 C)

@ @ @

Flash Point 80 F (C.C)(3) Autoignition Temp. 570 F(3)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.8 Upper 18.2(3)

Solubility

Cold water 67 parts water(1) Hot water Ethanol Soluble(1)

Others Soluble in ether(1)

Acid, Base Properties Slightly acidic(2)

Highly Reactive with Acid or acid fumes(3), oxidizing materials(3) forms insoluble salts with heavy metals(2), pyrophoric ferrous sulfide with iron(5)

Compatible with Glass, stainless steel(5), aluminum(5)

Shipped in

ICC Classification Coast Guard Classification

Comments Mfg(1) Pennwalt Corp., Phillips Petroleum Co. has penetrating leek-like odor.(1) Attacks copper and copper-bearing alloys.(5)

References (1) 1492 (4) 1571
(2) 1656 (5) 1697
(3) 1766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Methyl mercaptan (272)

IUC Name Methanethiol

Common Names Methyl mercaptan

MAC: ACGIH (Tentative); 50 ppm in air
LC for rats in air: 10,000 ppm(1)

Structural Formula

$CH_3SH$

Molecular wt. 48.11 Melting Pt. -121 C Boiling Pt. 6.1 - 6.2 C(1)

Density (Condensed) 0.868 @ 20/4 C(2) Density (gas) 1.66(2) @

Vapor Pressure (recommended 55 C and 20 C)

43.[illegible] psi @ [illegible] F(5) 2 atm @ 26.1 C(6) 5 atm @ 55.9 C

Flash Point [illegible] Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water Freely soluble(1) Hot water Slightly soluble(5) Ethanol

Others: Freely soluble in methanol(1)

Acid, Base Properties Slightly acidic(3)

Highly Reactive with: Will react with water, steam or acids to produce toxic and flammable vapors(2). Can react vigorously with oxidizing materials(2). Forms pyrophoric ferrous sulfide with iron(5).

Compatible with: glass, stainless steel, aluminum(5)

Shipped in: Tank trucks, tank cars, 800 lb cylinders

ICC Classification Flammable gas(2) Coast Guard Classification Inflammable gas(2)

Comments: Mfg(4): Air Products and Chemicals, Inc.; Pennwalt Corp. has odor of rotten cabbage(1), attacks copper and copper-bearing alloys(5)

References (1) 1492 (4) 1571
(2) 0766 (5) 1697
(3) 1656 (6) 1696

# HAZARDOUS WASTES PROPERTIES
# WORKSHEET

H. M. Name Butyl mercaptan (77)

IUC Name 1-butanethiol

Common Names Normal butyl thioalcohol(1)
Thiobutyl alcohol(1)
MAC: ACGIH (Tentative); 10 ppm in air(2)

Structural Formula

$CH_3(CH_2)_2CH_2SH$

Molecular Wt. 90.19 Melting Pt. -115.9 C Boiling Pt. 98.2 C

Density (Condensed) 0.8365 @ 25/4 C(2) Density (gas) ______ @ ______ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ ______ ______ @ ______

Flash Point ______ Autoignition Temp. ______

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility

Cold water Slightly soluble(1) Hot Water ______ Ethanol Very soluble(1)

Others: Very soluble in ether. liquid hydrogen sulfide(1)

Acid, Base Properties Slightly acidic(3)

Highly Reactive with Oxidizing materials, on contact with acid or acid fumes(2). Forms pyrophoric ferrous sulfide with iron(5). Attacks copper and copper-bearing alloys.

Compatible with Glass, stainless steel, aluminum(5)

Shipped in ______

ICC Classification ______ Coast Guard Classification Inflammable liquid(2)

Comments Mfg:(4) Pennwalt Corp.; Phillips Petroleum Co. Heavy skunk odor(1)

References (1) 1492 (4) 1571
(2) 0766 (5) 1697
(3) 1656

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Butyl mercaptan (77)

IUC Name 2-butanethiol[1]

Common names sec.-butyl mercaptan[2],
sec.-butyl thioalcohol[2]

Structural Formula

$CH_3CH_2CH(SH)CH_3$

Molecular wt 90.19  Melting Pt. -165 C  Boiling Pt. 84-85 C

Density (condensed) ____ @ ____ ____ Density (gas) ____ @ ____ ____

Vapor Pressure (recommended 55 C and 20 C)

____ @ ____  ____ @ ____  ____ @ ____

Flash Point ____  Autoignition Temp. ____

Flammability Limits in Air (wt %)  Lower ____  Upper ____

Explosive Limits in Air (wt. %)  Lower ____  Upper ____

Solubility

Cold water Slightly soluble[1]  Hot water ____  Ethanol Very soluble[1]

Others Very soluble in ether, liquid hydrogen sulfide[1]

Acid, Base Properties Slightly acidic[2]

Highly Reactive with Forms pyrophoric ferrous sulfide with [illegible][4]. Attacks copper and copper-bearing alloys[4]

Compatible with Glass, stainless steel, aluminum[4]

Shipped in ____

ICC Classification ____  Coast Guard Classification ____

Comments Mfg[3] Phillips Petroleum Co. Heavy skunk odor

References (1) 1452  (4) 1697
(2) 1656
(3) 1571

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Butyl mercaptan (7)

IUC Name 2-methyl-2-propanethiol[1]

Common Names tert -butyl mercaptan

Structural Formula

$(CH_3)_3CSH$

Molecular wt. 90.19 Melting Pt. -0.5 C Boiling Pt. 63.7 - 64.2 C

Density (condensed) ______ @ ______ Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ ______ ______ @ ______

Flash Point ______ Autoignition Temp ______

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility

Cold water slightly soluble[1] Hot water ______ Ethanol very soluble[1]

Others: very soluble in ether, liquid hydrogen sulfide[1]

Acid, Base Properties slightly acidic

Highly Reactive with forms pyrophoric ferrous sulfide with iron[4]. Flammable[1]

Attacks copper and copper bearing alloys[4]

Compatible with glass, stainless steel, aluminum

Shipped in ______

ICC Classification ______ Coast Guard Classification ______

Comments Mfg [3]: Phillips Petroleum Co. Heavy skunk odor.

References (1) 749 (4) 1697

(2) 1656

(3) [illegible]

## PROFILE REPORT

## Carbon Disulfide (98)

## 1. GENERAL

### Manufacture[1433,1501]

Carbon disulfide is made by the reaction of methane with sulfur in the presence of a silica gel catalyst in a multi-stage gas phase reactor at 570 to 620 C and 20 to 30 psig. Yields based on methane are 90 to 95 percent. The major by-product, hydrogen sulfide is converted back to sulfur in a two-stage reactor. Separation from a small amount of heavy ends (mercaptans and polysulfides) is done by distillation.

Reaction:

$$CH_4 + 4S \longrightarrow CS_2 + 2H_2S$$

Regeneration of sulfur:

$$2H_2S + 2O_2 \longrightarrow 2SO_2 + 2H_2O$$

$$SO_2 + 2H_2S \longrightarrow 3S + 2H_2O$$

Some major manufacturers are:[1433, 1718]

Pittsburgh Plate Glass Co., Chemical Division
S. Charleston, West Virginia

FMC Corporation, Inorganic Chemicals Division
S. Charleston, West Virginia

Stauffer Chemical Company,
Le Moyne, Alabama
Delaware City, Delaware

## Uses[2336,1433]

The major use of $CS_2$ is as an essential ingredient in the manufacture of xanthates and xanthides. These compounds are important intermediates in the manufacture of regenerated cellulosic products, such as viscose rayon, cellophane, cellulose sponge, non-woven fabrics, and others. Xanthates and their corresponding disulfides are also used as ore flotation agents, rubber vulcanization accelerators, and chain transfer agents in the polymerization field. Other carbohydrate xanthates, such as cereal starch xanthates, impart superior strength to paper products when added during the paper-making process.

The reaction of carbon disulfide with amines leads to carbamate derivatives, some of which are potent fungicides, and others which are useful in rubber vulcanization acceleration.

Carbon disulfide is a raw material in the manufacture of carbon tetrachloride, organic mercaptans, high-purity metal sulfides, thioureas, thiocyanates, trithiocarbamates, disulfide and monosulfide organic derivatives, and rhodanines, to name but a few of the many end-products.

As a solvent, carbon disulfide is an excellent solubilizer for oils, waxes, sulfur and sulfur compounds. In mixtures with light petroleum fractions it is used for removing paraffin from pipelines and oil well casings. Extraction of vegetable oils is carried out with carbon disulfide. Absorbent clays and petroleum catalysts, used in the petroleum refining industry, can be regenerated by extraction with carbon disulfide.

Carbon disulfide, in combination with other solvents, finds use in emulsion polymerization, and as nitrocellulose and polyvinyl solvents. It is used in the recovery of sulfur ores and as a solvent in the vapor-phase curing of rubber sheets.

In the agricultural field carbon disulfide mixtures are excellent grain fumigants, soil conditioners, herbicides, rodenticides and nematocides. Carbon disulfide is also used as an insecticidal fumigant for nursery stock and for soil treatment against beetles.

Other uses for carbon disulfide include treatment of wood to improve flexural strength, corrosion inhibition and de-worming of livestock.

### Physical and Chemical Properties

The physical and chemical properties of carbon disulfide are included in the attached work sheet.

## 2. TOXICOLOGY[0766,2336,2344]

Carbon disulfide poisoning is practically always caused by breathing its fumes (due to its volatility) although significant amounts can be absorbed through the skin. Skin contact can cause local inflammation.

The chief toxic effect is on the central nervous system, acting as a narcotic and anesthetic in acute poisoning with death following from respiratory failure. The anesthetic action is much more powerful than that of chloroform. In chronic poisoning, the effect on the nervous system is one of central and peripheral damage, which may be permanent if the damage has been severe. Sensory symptoms usually precede motor involvement. A secondary effect may be anemia.

In acute poisoning, early excitation of the central nervous system resembling alcoholic intoxication occurs, followed by depression with stupor, restlessness, unconsciousness and possibly death. If recovery occurs, the patient usually passes through the after-stage of narcosis with nausea, vomiting, headache, etc. In chronic poisoning, the picture is that of involvement of the nervous system, with neuritis and disturbance of the vision being the commonest early changes. Sensory changes such as crawling sensation of the skin, sensation of heaviness and coldness, and visual "veiling" of objects so that they appear indistinct, are noticed first. Often there is a pain in the affected parts, particularly in the limbs. These symptoms are followed by gradually increasing loss of strength. Wasting of muscles my occur. Mental symptoms vary from simple excitation or depression and irritability in the mild cases to mental deterioration, Parkinsonian paralysis and even insanity. These changes are accompanied by insomnia, loss of memory and personality changes, and chronic fatigue is a very common complaint.

The Threshold Limit Values (TLV) and Maximum Allowable Concentration (MAC) are 20 ppm and 60 mg/M$^3$ respectively.

## 3. OTHER HAZARDS

Carbon disulfide is a highly flammable, volatile liquid with a low flash point (-22 F), wide explosive range and an autoignition temperature of 100 C (212 F). Contact with exposed steam lines or the surface of an ordinary electric light bulb may cause ignition. Carbon disulfide vapor when mixed with air or oxygen in certain concentrations is flammable and explosive.[2236] Carbon disulfide reacts violently or explosively with azides, chlorine in the presence of iron, chlorine monoxide and fluorine.[1569]

## 4. DEFINITION OF WASTE MANAGEMENT PRACTICES

### Handling, Storage and Transportation

Due to the high degree of flammability and extreme volatility of carbon disulfide, strict ICC precautions regulate the loading, handling, transporting and labelling of containers. Non-sparking tools and hose connections must be used and the container should be grounded to prevent accumulation of static electricity. Transfer is accomplished by water padding, nitrogen displacement or pumping. Vapors should be purged from empty drums with steam while empty tank cars must have four "Dangerous Empty" placards in place.[2236,2344]

Drums and other containers of carbon disulfide should be stored in a cool, dry, and well-ventilated place away from acute fire hazards. Storage should be limited to minimize the hazard and the storage area should be of fire-resistant construction and equipped with sprinklers and/or portable fire extinguishers.[2336]

### Disposal, Use, Reuse[1433,2336]

The major use (65%) of carbon disulfide is in the production of cellophane and rayon by extraction of the desired compounds as xanthites. After extraction, the carbon disulfide is regenerated and reused.

Carbon disulfide is used as a chemical intermediate in the production of carbon tetrachloride, xanthates, xanthides and carbamates. Due to its toxicity and flammability, unreacted material is carefully recovered for reuse.

Carbon disulfide is also used as an extraction solvent for oils, waxes, sulfur, and sulfur compounds, as well as in emulsion polymerization and in the extractive regeneration of absorbent clays and petroleum catalysts. In these uses, the material is recycled indefinitely.

In the agricultural field, mixtures of carbon disulfide are used as grain fumigants, soil conditioners, herbicides, rodenticides and nematocides. This material escapes directly into the environment and cannot be recovered.

Recommended provisional limits for carbon disulfide in the environment are as follows:

| Contaminant and Environment | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Carbon disulfide in air | 0.2 ppm | .01 TLV |
| Carbon disulfide in water and soil | 1.0 ppm (mg/l) | Stokinger and Woodward Method |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No. 1 - Recycling

The industries that use carbon disulfide as a chemical intermediate or as a solvent recycle as much material as possible. This is the method of choice, whenever possible.

### Option No. 2 - Incineration

Unusable carbon disulfide solvents, as well as residues from manufacture, can be disposed of by controlled incineration. A sulfur dioxide scrubber is necessary when combusting significant quantities of carbon disulfide.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

The wastes generated in the manufacture and use of carbon disulfide can best be handled and treated at or near the site of generation by recycling or incineration. These methods are currently employed by most manufacturers and users of carbon disulfide as well as most industrial waste disposal facilities. Since these methods represent common industrial technology, carbon disulfide is not judged to be a candidate waste stream constituent for National Disposal Sites.

## 7. REFERENCES

1433. Kirk-Othmer encyclopedia of chemical technology. 3d ed. 22 v. New York. Interscience Publishers, 1966.

1501. Faith, W.L., D.B. Keyes, and R.L. Clark. Industrial chemicals. 3d ed. New York, John Wiley and Sons, Inc., 1965. 824 p.

1569. Manual of hazardous chemical reactions. Boston National Fire Protection Association, 1971. 308 p.

1710. Synthetic organic chemicals, U.S. production and sales, U.S. Government Printing Office, Washington, D.C., Publication TC-479, 260 p.

2336. Technical data sheet for carbon disulfide, New York, Stauffer Chemical Company, 1964, 36 p.

2344. Carbon disulfide chemical safety data sheet, SD-12, Washington, Manufacturing Chemists Association, 1967, 16 p.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Carbon disulfide (98)

IUC Name

Structural Formula

$CS_2$

Common Names carbon bisulfide, dithiocarbonic anhydride

Molecular wt. 76.14 Melting Pt. -112 C(1) Boiling Pt. 45 C(1)

Density (Condensed) 1.2628 @ 20 C(1) Density (gas) 2.67 @ 20 C(2)

Vapor Pressure (recommended 55 C and 20 C)

400 mm @ 28 C(1) 760 mm @ 46.5 C(1) @

Flash Point -30 F(2)
-22 F(4)

Autoignition Temp. 100 F(2)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper 50%(2,4)

Solubility

Cold water very slightly Hot Water Ethanol miscible(1)

Others: soluble chloroform, ether, benzene, carbon tetrachloride, oils(2).

Acid, Base Properties

Highly Reactive with air when hot surface is present, azides, chlorine (in presence of iron surface)(3), oxidizing materials(4).

Compatible with iron, aluminum, glass, porcelain, teflon(2).

Shipped in

ICC Classification Flammable liquid; red label Coast Guard Classification same

Comments Ref 2 has complete data.

References (1) 1570
(2) 1492
(3) 1569
(4) 0766

# PROFILE REPORT

## ALIPHATIC HALOGENATED HYDROCARBONS:

Carbon Tetrachloride (100), Chloral Hydrate (104), Chloroform (109), Dichlorofluoromethane (142), Dichloroethyl Ether (143), Dichloromethane (144), 1,2-Dichloropropane (145,363), 1-3-Dichloropropene (146), Dichlorotetrafluoroethane (147), Epichlorohydrin (171), Ethyl Chloride (180), Ethylene Dichloride (185), Methyl Chloroformate (269), Perchloroethylene (325), Polyvinyl Chloride (340), Tetrachloroethane (424), Trichloroethane (437), Trichlorofluoromethane (439), Vinyl Chloride (450)

## AROMATIC HALOGENATED HYDROCARBONS:

Chlorobenzene (Chlorobenzol)(108), -Dichlorobenzene (140,278), p-Dichlorobenzene (141), Trichlorobenzene (436), Hexachlorophene (497)

## 1. GENERAL

### Introduction

The halogenated hydrocarbons treated in this report have all been selected as probable candidate waste stream constituents for industrial disposal. These materials are similar in that most are commodity chemicals with relatively low toxicity, well-defined and safe methods of industrial handling and common methods of disposal. The halogenated hydrocarbons are, therefore, discussed as a class in this report.

### Manufacture

Most of this group of chemicals are produced by chlorination of the parent hydrocarbon by addition and/or substitution reactions. Addition of chlorine to a double bond (Equation 1) yields no side products and the selectivity is nearly 100 percent. By contrast, substitution (Equations 2 and 3)

(1) $R\text{-}CH{=}CH\text{-}R + Cl_2 \longrightarrow R\text{-}CHClCHCl\text{-}R$ addition

(2) $Ar\text{-}H + Cl_2 \longrightarrow Ar\text{-}Cl + HCl$ substitution

(3) $R\text{-}H + Cl_2 \longrightarrow R\text{-}Cl + HCl$ substitution

results in the formation of hydrogen chloride as a by-product and has a selectivity less than 90 percent. The side products are usually isomers containing more or less chlorine than the desired product.[1655,1501] Several steps may be necessary to produce the desired compound in a series of addition and substitution reactions. The crude products can contain isomers, side products, hydrochloric acid, chlorine and varying amounts of chlorinated sludge. Thus all commercial processes have units for removing hydrochloric acid and chlorine and a final distillation is used to remove isomers and "heavy bottoms."

Vinyl chloride is made by pyrolysis of ethylene dichloride (or related technology) and the fluorochlorohydrocarbons are made from the corresponding chloro compounds by displacement of the required amount of chlorine by hydrofluoric acid in the presence of antimony pentachloride.[0534,1433,1501]

## Uses

The fluorochlorohydrocarbons (Freons®) are used principally as refrigerants and aerosol propellants due to their chemical inertness, non-flammability, non-toxicity and almost total lack of allergenic reactions.[1433]

Chlorinated hydrocarbons have excellent solvent properties. By varying the basic hydrocarbon (usually methane, ethane, ethylene or benzene) and the amount of chlorine substitution, a wide range of solvent specificity and operating temperatures can be obtained. In addition, they are simple and relatively cheap to prepare and have a high degree of chemical stability. For these reasons, they are widely used as solvents for oils, fats, lacquers, resins, varnishes, extraction solvents for natural products, solvents for organic reactions, degreasers and dry cleaning agents.

The chlorinated hydrocarbons, because of their relatively low toxicity have also found use as soil fumigants (carbon tetrachloride, 1,3-dichloropropene, dichloroethylene, tetrachloroethane), insecticides ([illegible]- and [illegible]-dichlorobenzene, carbon tetrachloride, tetrachloroethylene, trichlorobenzene), disinfectants (hexachlorophene), and various medical and veterinary uses (chloral, ethyl chloride, carbon tetrachloride, chloroform, tetrachloroethylene, trichloroethylene) as well as food additives (ethylene dichloride, hexachlorophene).[1492,1506,2253]

Many of these compounds are used as starting materials in organic synthesis. Chloroform, carbon tetrachloride, perchloroethylene and others are used to make refrigerants, aerosols and propellants (Freons®).[1433,1506,1655] Chloral hydrate and chlorobenzene are used in the manufacture of DDT, ethyl chloride is used to make tetraethyl lead, ethylene dichloride is a precursor to vinyl chloride, chlorobenzene is used to manufacture phenol and aniline and methyl chloroformate is used in a variety of organic syntheses.[1492,1506]

The higher boiling chlorohydrocarbons, chlorobenzene, and o-dichlorobenzene are used as heat transfer media.[1492] Vinyl chloride is used to make polyvinyl chloride and epichlorohydrin is used in epoxy resins.[1492,1506]

### Physical and Chemical Properties

The physical and chemical properties of the compounds discussed in this report are included in the attached worksheets.

## 2. TOXICOLOGY[0766,1433,1492,2253]

### Chlorinated Aliphatic Hydrocarbons

The substitution of a chlorine atom for a hydrogen greatly increases the anaesthetic action of a member of the aliphatic hydrocarbon series. In addition,the chlorine derivative is usually less specific in its action and may affect other tissues of the body in addition to those of the central nervous system; in many cases, the chlorine derivative is quite toxic. For example, chloroform, in addition to its narcotic qualities, may cause liver, heart and kidney damage.

As a general rule, the unsaturated chlorine derivatives are highly narcotic but less toxic than the saturated derivatives, thus causing degenerative changes in the liver and kidneys less frequently. In the saturated group, the narcotic effect is enhanced with an increase in the number of chlorine atoms. However, there is less relationship between the number of chlorine atoms present and the toxicity of the compound.

In dealing with these chlorinated hydrocarbons, it must be remembered that a toxic action may result from repeated exposure to concentrations which are too low to produce a narcotic effect, and which consequently, are too low to give warning of danger. Individual susceptibility is also important when poisoning by this group of solvents is being considered. Certain workmen may be seriously affected by concentrations that seem to have no effect on fellow employees in the same exposure.

The chlorinated hydrocarbons are also irritants to the eyes and the mucous membranes. Repeated direct exposure to the skin may result in dermatitis and poses the additional danger of absorption through the skin.

The chlorofluorohydrocarbons have a very low level of toxicity and are almost completely non-allergenic. The primary danger associated with these materials is that very high concentrations cause narcosis and anaesthesia.

## Chlorinated Aromatic Hydrocarbons

In most instances, it is difficult to predict the toxicity of these compounds. However, in the case of most aromatic chlorine compounds, their toxicity is usually no greater, and frequently less, than that of the corresponding aromatic hydrocarbons.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) that have been established are:

| 1. Chlorinated Aliphatic Hydrocarbons | TLV | | MAC |
|---|---|---|---|
| | ppm | mg/M$^3$ | ppm |
| Carbon Tetrachloride | 10 | 65 | 25 |
| Chloral Hydrate | - | - | - |
| Chloroform (Trichloromethane) | 25 | 120 | 50 |
| Dichlorofluoromethane (Freon 12) | 1,000 | 4,950 | 1,000 |
| Dichloroethyl Ether | 5 | 30 | - |
| 1,2-Dichloropropane | 75 | 350 | 75 |
| 1,3-Dichloropropene | - | - | - |
| Dichlorotetrafluoroethane (F 114) | 1,000 | 7,000 | - |
| Epichlorohydrin | 5 | 19 | - |
| Ethyl Chloride (Chloroethane) | 1,000 | 2,600 | 1,000 |

1. Cont'd

| | TLV | | MAC |
|---|---|---|---|
| | ppm | mg/M$^3$ | ppm |
| Ethylene Dichloride (Dichloroethylene) | 50 | 200 | 50 |
| Methyl Chloroformate | - | - | - |
| Perchloroethylene | 100 | 670 | |
| Polyvinyl Chloride | - | - | - |
| Tetrachloroethane | 5 | 35 | - |
| Dichloromethane | 500 | 1,740 | 500 |
| Trichloroethane | 350 | 1,900 | 500 |
| Trichloroethylene | 100 | 535 | 100 |
| Trichlorofluoromethane | 1,000 | 5,600 | - |
| Vinyl Chloride | 200 | 770 | - |

2. Chlorinated Aromatic Hydrocarbons

| | | | |
|---|---|---|---|
| Chlorbenzene (Chlorbenzol) | 75 | 350 | 75 |
| -Dichlorobenzene | 50 | 300 | 50 |
| -Dichlorobenzene | 75 | 456 | 75 |
| Trichlorobenzene | - | - | - |
| Hexachlorophene (Methylene) | - | - | - |

## 3. OTHER HAZARDS

All chloro-, chlorofluoro- and bromohydrocarbons, when heated to decomposition, give off noxious and highly toxic fumes. The fumes consist of the corresponding halo-acids, the free halogens and, in the case of chlorine containing compounds, phosgene.[0766,1492,1569] In addition, these compounds will also react, sometimes explosively, when they come into contact with the alkaline and alkaline earth metals, and may be very corrosive to aluminum, especially under abrasive conditions.[1569,2253] These compounds have a wide range of flammability and tendency to explode (noted in the respective worksheets); none are shock-sensitive or subject to detonation.

## 4. DEFINITION OF ADEQUATE WASTE MANAGEMENT

### Handling, Storage, and Transportation

The halogenated hydrocarbons are all toxic to a certain extent by inhalation or skin contact. These materials should be handled in a well-ventilated area and protective clothing and respirators are recommended where necessary. In cases of accidental contact, all contaminated clothing should be removed instantly and the skin washed thoroughly with soap and water.[0096,1811,2253]

Storage of these materials should be in cool, dry, well-ventilated areas, away from acute fire hazards. Materials with low boiling points should be protected from excessive heat and against sudden rise in temperature.

These materials are shipped under a variety of U.S. Department of Transportation (DOT), U.S. Coast Guard and IATA regulations. Most regulations relate to the flammability and volatility of these compounds.[0018,2253,1569] Information on safe handling and use of these compounds can be found in the Chemical Data Sheets published by the Manufacturing Chemists Association,[1809,2254] standard reference sources for manufacturers' Technical Data Sheets.[2253]

### Disposal/Reuse

Commercial operations that use chlorinated compounds for dry cleaning, degreasing, and as solvents, usually have on-site reclaiming procedures that recycle the materials indefinitely.[2255,2256,2257] In most operations, there is a finite loss to the atmosphere and the materials must be constantly replenished. There is usually no provision for solvent exchange but there are commercial solvent reclaimers who will re-possess contaminated solvents.[2257,2258]

The fluorohydrocarbons are used indefinitely or until equipment failure results in their release into the atmosphere.[2261] The aerosol propellants are discharged directly into the air and are not recoverable.

In manufacture, recycling and reclaiming, there is a solid, semi-solid or liquid residue containing varying amounts of solvent and chlorinated and non-chlorinated materials. In the manufacture of ethylene dichloride/vinyl chloride, this sludge represents approximately 1 percent of the total raw materials used, or 50 to 70,000,000 lb per year.[2259] Present practice is to dispose of this material by landfill.[2259,2260] It is not known whether the complete elmination of atmospheric losses resulting in indefinite recycling of solvents will generate a severe reclaiming problem.

The users of very large volume chemical intermediates (ethyl chloride, ethylene dichloride, vinyl chloride, chloroform, carbon tetrachloride, perchloroethylene, epichlorhydrin, etc.,) completely recycle any unused materials after a stripping/purification step.[0534,1501,2259,2260]

The halogenated products considered in this report do not usually come into contact with aqueous media during manufacture except in special cases. Therefore, the discharge of dilute aqueous waste streams is not a problem. In most cases, small amounts of dispersed halocarbons can be removed by settling and the small amounts dissolved may be removed by lagooning and slow evaporation.[0534,1501]

Recommended provisional limits for the compounds discussed in this report are listed below.

| Contaminant in Air | Provisional Limit | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M$^3$ | |
| Carbon tetrachloride | 0.1 | 0.65 | 0.01 TLV |
| Chloral hydrate | - | 0.002 | Based on similar compounds |
| Chloroform | 0.25 | 1.2 | 0.01 TLV |
| Dichlorofluoromethane | 10 | 49.5 | 0.01 TLV |
| Dichloroethyl ether | 0.05 | 0.30 | 0.01 TLV |
| 1,2-Dichloropropane | 0.75 | 3.5 | 0.01 TLV |
| 1,3-Dichloropropene | - | 0.03 | Based on similar compounds |
| Dichlorotetrafluoroethane | 10 | 70 | Based on similar compounds |
| Epichlorohydrin | 0.05 | 0.19 | Based on similar compounds |

(Cont'd)

| Contaminant in Air | Provisional Limit | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M$^3$ | |
| Ethyl chloride | 10 | 26 | 0.01 TLV |
| Ethylene dichloride | 0.5 | 2.0 | 0.01 TLV |
| Methyl chloroformate | - | 0.03 | Based on similar compounds |
| Perchloroethylene | 1.0 | 6.70 | 0.01 TLV |
| Polyvinyl chloride | - | - | Insufficient data |
| Tetrachloroethane | 0.05 | 0.35 | 0.01 TLV |
| Trichloroethane | 3.5 | 19 | 0.01 TLV |
| Trichloroethylene | 1.0 | 5.35 | 0.01 TLV |
| Trichlorofluoromethane | 10 | 56 | 0.01 TLV |
| Vinyl chloride | 2.0 | 7.70 | 0.01 TLV |
| Chlorobenzene | 0.75 | 3.5 | 0.01 TLV |
| -Dichlorobenzene | 0.50 | 3.0 | 0.01 TLV |
| -Dichlorobenzene | 0.75 | 4.5 | 0.01 TLV |
| Trichlorobenzene | - | 3.0 | Based on similar compounds |
| Dichloromethane | 5 | 17.4 | 0.01 TLV |
| Hexachlorophene | - | - | Insufficient data |

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Carbon tetrachloride | 1.95 | Stokinger and Woodward Method |
| Chloral hydrate | 0.01 | Based on similar compounds |
| Chloroform | 6 | Stokinger and Woodward Method |
| Dichlorofluoromethane | 247.5 | Stokinger and Woodward Method |
| Dichloroethyl ether | 1.5 | Stokinger and Woodward Method |
| 1,2-Dichloropropane | 17.5 | Stokinger and Woodward Method |
| 1,3-Dichloropropene | 0.15 | Based on similar compounds |
| Dichlorotetrafluoroethane | 350 | Stokinger and Woodward Method |
| Epichlorohydrin | 0.95 | Stokinger and Woodward Method |
| Ethyl chloride | 130 | Stokinger and Woodward Method |
| Ethylene dichloride | 10 | Stokinger and Woodward Method |

(Cont'd)

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Methyl chloroformate | 0.15 | Based on similar compounds |
| Perchloroethylene | 33.50 | Stokinger and Woodward Method |
| Polyvinyl chloride | - | Insufficient data |
| Tetrachloroethane | 175 | Stokinger and Woodward Method |
| Trichloroethane | 19 | Stokinger and Woodward Method |
| Trichloroethylene | 26.75 | Stokinger and Woodward Method |
| Trichlorofluoromethane | 280 | Stokinger and Woodward Method |
| Vinyl chloride | 38.50 | Stokinger and Woodward Method |
| Chlorobenzene | 17.5 | Stokinger and Woodward Method |
| -Dichlorobenzene | 15.0 | Stokinger and Woodward Method |
| -Dichlorobenzene | 22.5 | Stokinger and Woodward Method |
| Trichlorobenzene | 15.0 | Based on similar compounds |
| Dichloromethane | 87 | Stokinger and Woodward Method |
| Hexachlorophene | - | Insufficient data |

## 5. EVALUATION OF WASTE MANAGEMENT PRACTICES

### Option No.1 - Recycling

The dry cleaning, refrigeration, degreasing and solvent extraction industries, as well as processors using halocarbons as raw materials, all recycle as much of their halocarbons as possible. For small users or companies with badly contaminated lots, commercial solvent reclaimers reprocess the materials for further use.[2255,2256,2257,2261]

### Option No.2 - Incineration

Badly contaminated solvents that cannot be reclaimed, as well as chlorinated and non-chlorinated residues and sludges, can be disposed of by incineration. Some of the materials, especially those with high chlorine content may not support combustion by themselves, but can be burned if an auxiliary fuel is used. Care must be exercised to assure complete combustion. An acid scrubber is necessary to remove the halo acids produced. In this manner, both long- and short-term environment effects are eliminated at the sources in one simple disposal step.

### Option No.3 - Landfill of Residue and Sludges Obtained During Manufacture or Use

The total production of the major halocarbons exceeded 16 billion lb in 1970. If one makes the conservative estimate that byproduct production of chlorine-containing residues and sludges is equivalent to 1 percent of production, at least 160 million lb (80,000 tons) of unusable material must be disposed of each year. Presently, this material is collected by various commercial scavengers and landfilled, often in remote places.[1501, 2259,2260] The dry cleaning, degreasing and solvent recovery industries, as well as the industries that use halocarbons for raw materials, also generate sludge of waste solids but with very much lower chlorine content. These wastes, especially the smaller smounts, are often landfilled locally.[2256]

Deposit by landfill of halogen-containing waste, especially those which are generated in the production of chlorinated hydrocarbons, presents a serious long-term environmental hazard to man, animals and fish. These materials are toxic and to some extent water soluble. Biodegradation will further increase their mobility. Thus, landfill disposal of these wastes represents an excessive, long-term threat to underground water supplies and must be considered much less acceptable than Option No.2 (incineration). Option No.3 is acceptable only when the landfill site is totally isolated from ground and surface water and meets California Class 1 standards.

## 6. APPLICABILITY TO NATIONAL DISPOSAL SITES

Most of the wastes generated by the industries that produce and use these materials can best be handled and treated at the site of generation by incineration. This includes wastes that are presently landfilled by private scavengers. These scavengers could also set up incineration sites in those cases where size and economics make this the preferred method of disposal. Incineration should be available at National Disposal Sites for situations where both the industry generating the waste and the local scavenging industry cannot handle the waste safely. However, except in extreme cases, the halogenated aliphatic hydrocarbons discussed in this report are not judged to be candidate waste stream constituents requiring National Disposal Site treatment.

## 7. REFERENCES

0096. Fire protection guide on hazardous materials, 3d ed. Boston, National Fire Protection Association, 1969. 91 p.

0534. Jones, H.E. Environmental control in the organic and petrochemical industries. Park Ridge, New Jersey, Noyes Data Corporation, 1971. 257 p.

0766. Sax, I.R. Dangerous properties of industrial materials. 3d ed. New York, Reinhold Publishing Corporation, 1968. 1,251 p.

1433. Kirk-Othmer encyclopedia of chemical technology. 3d ed. 22 v. New York, Interscience Publishers, 1966.

1492. Merck index of chemicals and drugs, 7th ed. Rahway, New Jersey, Merck Company, Inc., 1960. 1,634 p.

1501. Faith, W.L., D.B. Keyes, and R.L. Clark. Industrial chemicals. 3d ed. New York, John Wiley and Sons, Inc., 1965. 824 p.

1506. Oil, paint and drug reporter profiles. New York, Schnell Publishing Company, Inc., 1970.

1569. Manual of hazardous chemical reactions. Boston National Fire Protection Association, 1971. 308 p.

1655. Fieser, L.F. and M. Fieser. Organic chemistry. 3d ed. Boston, P.C. Heath & Company, 1956. p 145-160, 644-655.

1809. Ethylene Dichloride Chemical Safety Data Sheet SD-18. Washington, Manufacturing Chemists Association, 1970.

1811. Methyl Chloride Chemical Safety Data Sheet SD-40. Washington, Manufacturing Chemists Association, 1970.

2253 Technical Data Sheet for Organic Chlorine Compounds. New York, Union Carbide Chemical Company, 1960. 44 p.

2254. Carbon Tetrachloride Chemical Safety Data Sheet, SD-3. Washington, Manufacturing Chemists Association, 1970.

2255. Personal communication, Joseph Elich, Van Waters & Rogers United, to J.W. Hamersma, TRW Systems, Aug.15, 1972.

2256. Personal communication, Richard Wilson, E.I. DuPont De Nemours Company, to J.W. Hamersma, TRW Systems, Aug.15, 1972.

2257. Personal communication, William Calvin, Hooker Chemical Corporation, to J.W. Hamersma TRW Systems, Aug.15, 1972.

2258. Personal communication, Thomas Schenley, Service Chemical Corporation, to J.W. Hamersma, TRW Systems, Aug.24, 1972.

2259. Personal communication, Mr. King, American Chemical Corporation, to J.W. Hamersma, TRW Systems, Aug.15, 1972.

2260. Personal communication, Richard Crocker, Chevron Research Corporation, to J.W. Hamersma, TRW Systems, July 1969.

2261. Personal communication, Don Beck, Sweet Anderson, TRW Systems, to J.W. Hamersma, TRW Systems, Aug.14, 1972.

HAZARDOUS WASTES PROPERTIES
WORKSHEET

[illegible] Name Dichloromethane (144)

IUC Name

Common Names Methylene Chloride

Structural Formula

$CH_2Cl_2$

Molecular wt 84.94 (1)  Melting Pt. -96.7 C (1)  Boiling Pt. 40.1 C (1)

Density (condensed) 1.326 g/cc @ 20/4 C (1)  Density (gas) 2.93 (1) @

Vapor Pressure (recommended 55 C and 20 C)

380 mm @ 22 C  @  @

Flash Point  Autoignition Temp. 1224 F

Flammability Limits in Air (wt %) Lower  Upper

Explosive Limits in Air (wt. %) Lower  Upper

Solubility:

Cold water slightly soluble  Hot water slightly soluble  Ethanol totaly soluble

Others: totaly soluble in ether

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

DOT Classification  Coast Guard Classification

Comments

References (1) 0766
(2) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethyl Chloride (180)

IUC Name Chloroethane

Common Names Hydrochloric Ether
Muriatic Ether

Structural Formula
$C_2H_5Cl$

Molecular wt. 64.54 Melting Pt. -138.7 C[1] Boiling Pt. 13.1 C[1]

Density (Condensed) .9028 @15/4 C[1] Density (gas) 2.22 F[2] @

Vapor Pressure (recommended 55 C and 20 C)

2 atm @ 32.5 C[1] 5 atm @ 64.0 C[1] 20 atm @ 127.3 C[1]

Flash Point [illegible] Autoignition Temp. 966 F[2]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 3.8%[2] Upper 15.4%[2]

High fire hazard

Solubility

Cold water slightly Hot water insoluble Ethanol very

Others: Miscible ether

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in [illegible]

ICC Classification Flammable liquid - red label Coast Guard Classification red label

Comments

References [illegible]

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Epichlorohydrin (171)

IUC Name 1-chloro-2,3-epoxypropane

Common Names α-epichlorohydrin
γ-chloropropylene oxide
chloromethyloxirane

Structural Formula

$C_3H_5ClO$

Molecular wt. 92.53 Melting Pt. -48 C(1) -57.1 C(2) -25.6 C(2) Boiling Pt. 116.5 C(1)

Density (Condensed) 1.1801 @ 20/4(1) Density (gas) 3.29 (2) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 16.6 C(2) 100 mm @ 62 C(3) 400 mm @ 98 C(3)

Flash Point 105 F [illegible] Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water slightly Hot Water decomposes Ethanol

Others: soluble benzene, ether, chloroform, trichloroethylene, carbon tetrachloride, immiscible petroleum hydrocarbons(3)

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments

References (1) 1570
(2) 0766
(3) [illegible]

## HAZARDOUS WASTES PROPERTIES WORKSHEET

H. M. Name Dichlorotetrafluoroethane (147)

IUC Name 1,1-dichloro-1,2,2,2-tetrafluoroethane

Common Names F-114 (Freon-114)

Structural Formula

$CCl_2FCF_3$

$C_2Cl_2F_4$

Molecular wt. 170.92(2) Melting Pt. -94(2) Boiling Pt. 3.5 C(1)

Density (Condensed) @ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

13 psig @ 70 F(3) @ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water insoluble(2) Hot Water insoluble(2) Ethanol soluble(2)

Others: soluble ether(2)

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in steel cylinders

ICC Classification Coast Guard Classification

Comments

References (1) 766 (649)

(2) 1570

(3) Air products catalogue

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name 1,3-dichloropropene (146)

IUC Name 1,3-dichloropropene

Common Names α,γ-dichloropropylene
1,3-dichloropropylene
γ-chloroallyl chloride

Structural Formula

$C_3H_4Cl_2$

Molecular wt. 110.98 Melting Pt. ______ Boiling Pt. 108 C(1)

Density (Condensed) 1.220(1) @ 25 C(1) Density (gas) 3.8 @ ______

Vapor Pressure (recommended 55 C and 20 C)

______ @ ______ ______ @ ______ ______ @ ______

Flash Point 93 F(2) Autoignition Temp. ______

Flammability Limits in Air (wt %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility

Cold Water insoluble Hot Water ______ Ethanol soluble

Others: soluble chloroform

Acid, Base Properties neutral

Highly Reactive with ______

Compatible with ______

Shipped in ______

ICC Classification ______ Coast Guard Classification ______

Comments The physical constants are for the equilibrium. Mixture of cis and trans isomers.

References (1) 1492
(2) 0766

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Dichloroethylether (143)

Structural Formula

$C_4H_8Cl_2O$

IUC Name 1-chloro-2-(B-chloroethoxy)ethane

Common Names , -dichloroethylether, chlorex
sym-dichloroethylether
1,2-dichlorodiethylether

Molecular wt. 143.02(1) Melting Pt. ____ Boiling Pt. ____

Density (Condensed) 1.22 @ 20/20 C(1) Density (gas) 1.182 @ 19/19 C(2)

Vapor Pressure (recommended 55 C and 20 C)

0.7 mm @ 20 C(3) 100 mm @ 62 C(2) 40 mm @ 91.5 C(2)

Flash Point 131 F (C.C.)(3) Autoignition Temp. 696 F(3)

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold water insoluble(1) Hot Water ____ Ethanol soluble(1)

Others: most organic solvents(1)

Acid, Base Properties ____

Highly Reactive with explosive hazards common with ethers(3), reacts with water, oxidizing materials(3).

Compatible with ____

Shipped in ____

ICC Classification ____ Coast Guard Classification ____

Comments ____

References (1) 1492
(2) 1570
(3) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Dichlorodifluoromethane (142)

IUC Name Dichlorodifluoromethane

Common Names Freon-12, Frigen-12, Gentron-12, Isotron-12, Halon, Arcton-6

Structural Formula

$CCl_2F_2$

Molecular wt. 120.92(1) Melting Pt. -158 C(1) Boiling Pt. -29 C(1)

Density (Condensed) ____ @ ____ Density (gas) ____ @ ____

Vapor Pressure (recommended 55 C and 20 C)

5 atm @ 16.1 C(1) 70 psig @ 70 F(1) ____ @ ____

Flash Point ____ Autoignition Temp. ____

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold Water insoluble(3) Hot water ____ Ethanol soluble(2)

Others: soluble ether

Acid, Base Properties neutral

Highly Reactive with non-corrosive(3)

Compatible with ____

Shipped in STEEL CYLINDERS

ICC Classification Non-flammable, green label

IATA nonflammable

Coast Guard Classification Non-flam., green(1)

Comments ____

References (1) 0766

(2) 1570

(3) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Chloroform (109)

IUC Name Trichloromethane

Common Names

Structural Formula

$CHCl_3$

Molecular wt. 119.38(1) Melting Pt. -63.5 C(1) Boiling Pt. 61.2 C(1)

Density (Condensed) 1.4916 @ 18 C(1) Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

15 psig @ 84 C(1) 60 psig @ 120 C(1) @

Flash Point non-flammable(2) Autoignition Temp.

Flammability Limits in Air (wt %) Lower non-flammable(2) Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water slightly(2) Hot water slightly(2) Ethanol miscible(2)

Others: miscible in all proportions ether, acetone, benzene, ligroin(2)

Acid, Base Properties neutral

Highly Reactive with aluminum and magnesium powder; impact sensitive with alkali metals; highly exothermic reaction with alcohols plus base. Forms explosive mixture with nitrogen tetroxide(3)

Compatible with

Shipped in steel drums

ICC Classification Coast Guard Classification

Comments MCA warning label(4), decomposes to phosgene when heated to decomposition(4)
TLV (accepted) 50 ppm; 240 mg/m3(4)

References (1) 1570 (4) 0766
(2) 1492
(3) 1559

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. W. Name Chloral hydrate (104)

IUC Name 2,2,2-Trichloro-1,1-ethanediol

Common Names Trichloroacetaldehyde monohydrate

Structural Formula

$C_2H_3Cl_3O_2$

Molecular wt. 165.42$^{(1)}$ Melting Pt. 57 C$^{(1)}$ Boiling Pt. 98 C$^{(1)}$

Density (Condensed) 1.9081 @ 20 C$^{(2)}$ Density (gas) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm$^{(solid)}$ @ 20 C$^{(2)}$ 100 mm @ 55 C$^{(2)}$ @

Flash Point Autoignition Temp.

Flammability Limits in Air (wt %) Lower slight$^{(3)}$ Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold water very soluble$^{(1)}$ Hot water very soluble$^{(1)}$ Ethanol very soluble$^{(1)}$

Others very soluble in chloroform, ether, carbon disulfide, glycerol, olive oil, benzene, toluene, turpentine$^{(1)}$

Acid, Base Properties acidic

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments Complete medical data in Refs. 2 & 3

References (1) 1492

(2) 1570

(3) 0766

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Carbon tetrachloride (100)

IUC Name Tetrachloromethane

Common Names [illegible]

Structural Formula

$CCl_4$

Molecular wt. [illegible] Melting Pt. -22.96 C[1] Boiling Pt. 76.75 C[1]

Density (condensed) 1.594 [illegible][1] Density (gas) ______ @ ______

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ [illegible][1] 400 mm @ 58.0 C[1] ______ @ ______

Flash Point none Autoignition Temp. ______

Flammability Limits in Air (wt. %) Lower ______ Upper ______

Explosive Limits in Air (wt. %) Lower ______ Upper ______

Solubility

Cold water insoluble[1] Hot water insoluble[1] Ethanol soluble[1]

Others: soluble in ether, benzene, chloroform, carbon disulfide, petroleum ether, oils.

Acid, Base Properties neutral

Highly reactive with May be reactive with alkaline or alkaline earth metals under proper conditions[1]

Compatible with ______

Shipped in ______

ICC Classification ______ Coast Guard Classification ______

Comments: forms phosgene at high temperatures[2]

References (1) [illegible]

(2) [illegible]

(3) [illegible]

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Ethylene dichloride (185)

IUC Name 1,2-Dichloroethane

Common Names Ethylene chloride

sym-Dichloroethane, Dutch liquid, [illegible]

Structural Formula

$C_2H_4Cl_2$

Molecular Wt. 98.96 Melting Pt. -35 C(1) Boiling Pt. 84 C(1)

Density (Condensed) 1.25 @ 20/4 C(1) Density (gas) 3.4(2) @

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ 29.4 C(2) @

Flash Point 56 F Autoignition Temp. 775 F(2)

Flammability Limits in Air (wt %) Lower Upper [illegible](2)

Explosive Limits in Air (wt. %) Lower 6.2 Upper 15.9(2)

Solubility

Cold Water slightly(1) Hot Water Ethanol very(1)

Others ether, chloroform(1)

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification flammable liquid, red(2) IATA: red(2) Coast Guard Classification red label(2)

Comments

References (1) 1570

(2) 0766

(3) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Perchloroethylene (325)

IUC Name Tetrachloroethene

Common Names Tetrachloroethylene, ethylene tetrachloride, carbon dichloride, many trade names[2]

Structural Formula

$C_2Cl_4$

Molecular wt. 165.8 Melting Pt. -23.35 C[1] Boiling Pt. 121.20 C[1]

Density (Condensed) 1.631 @ 15/4 C[1] Density (gas) ____ @ ____

Vapor Pressure (recommended 55 C and 20 C)

[illegible] mm @ 22 C[1] ____ @ ____ ____ @ ____

Flash Point none Autoignition Temp. ____

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold water 100 ppm[2] Hot water ____ Ethanol miscible[2]

Others: miscible ether, chloroform, benzene[2]

Acid, Base Properties ____

Highly Reactive with extremely stable and resists hydrolysis[1].

Compatible with ____

Shipped in ____

ICC Classification IATA: other restricted articles, Class A. Coast Guard Classification ____

Comments ____

References (1) 766

(2) 442

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Propylene dichloride (365)

IUC Name 1,2-Dichloropropane

Common Names

Structural Formula

$C_3H_6Cl_2$

Molecular wt. 112.99 Melting Pt. -100.42 C(2) Boiling Pt. 96.8 C(1)

Density (condensed) 1.1583 @ 20/20 C(1) Density (gas) 3.9 @

Vapor Pressure (recommended 55 C and 20 C)

40 mm @ 19.4 C(1) @ @

Flash Point [illegible](1) Autoignition Temp. 1035 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 3.4(1) Upper 14.5(1)

Solubility

Cold water slightly(1) Hot water Ethanol

Others: common organic solvents

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid, red label(1) Coast Guard Classification

Comments

References (1) 766 (640)
(2) 1570 (1-400)

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Trichloroethylene (438)

IUC Name Trichloroethene

Common Names ethinyl trichloride, ethylene trichloride, many trade names(1)

Structural Formula ClCH=CCl2

fp -86.8 C(1)

Molecular wt. 131.39 Melting Pt. -73 C Boiling Pt. 87.1 C(1)

Density (condensed) 1.4556 @ 25/4 C(1) Density (gas) 4.53(1) @

Vapor Pressure (recommended 55 C and 20 C)

100 mm @ 32 C(1) @ @

Flash Point none(1) Autoignition Temp. 770 F(1)

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.5(1) Upper 90(1)

Solubility

Cold water slightly Hot water Ethanol ∞

Others: soluble in most organic solvents

Acid, Base Properties neutral

Highly Reactive with Should be stored away from light, especially when moist.(2)

Compatible with

Shipped in

ICC Classification IATA: other restricted articles, Class A Coast Guard Classification

Comments

References (1) 766
(2) 1497

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Trichlorofluoromethane (439)

IUC Name Fluorotrichloromethane

Common Names Fluorotrichloromethane, Freon-11

Structural Formula

$CCl_3F$

Molecular wt. 137.38 Melting Pt. -111 C(1) Boiling Pt. 24.1 C(1)

Density (condensed) 1.494 @ 17.2 C(1) Density (gas) ____ @ ____ °

Vapor Pressure (recommended 55 C and 20 C)

____ @ ____ ° ____ @ ____ ° ____ @ ____ °

Flash Point ____ Autoignition Temp. ____ °

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold Water ____ Hot Water ____ Ethanol ____

Others: ____

Acid, Base Properties neutral

Highly Reactive with ____

Compatible with ____

Shipped in ____

ICC Classification ____ Coast Guard Classification ____

Comments ____

References (1) [illegible]

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Hexachlorophene (497)

IUC Name (2-hydroxy-3,4,6-trichlorophenyl) methane

Common Names Hexosan
G-11
2,2'-Methylene bis (3,4,6-tricholophenol)

Structural Formula

$C_{13}H_6Cl_6O_2$

Molecular wt. 406.9
Melting Pt. 165 C(1)
Boiling Pt. ____

Density (Condensed) ____ @ ____
Density (gas) ____ @ ____

Vapor Pressure (recommended 55 C and 20 C)

____ @ ____
____ @ ____
____ @ ____

Flash Point ____
Autoignition Temp. ____

Flammability Limits in Air (wt %) Lower ____ Upper ____

Explosive Limits in Air (wt. %) Lower ____ Upper ____

Solubility

Cold water soluble (pH 9-10)(2)
Hot water ____
Ethanol soluble(2)

Others soluble ether, acetone, chloroform

Acid, Base Properties weakly acidic

Highly Reactive with ____

Compatible with ____

Shipped in ____

ICC Classification ____
Coast Guard Classification ____

Comments ____

References (1) 3266
(2) 1670

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name o-Dichlorobenzene (140)

IUC Name 1,2-Dichlorobenzene

Common Names

Structural Formula

$C_6H_4Cl_2$

Molecular wt. 147

Melting Pt. -17 C[1]

Boiling Pt. 179 C[1]

Density (Condensed) 1.3048 @ 20/4 C[1]

Density (gas) 5.05[2] @

Vapor Pressure (recommended 55 C and 20 C)

@

@

@

Flash Point 151 F[2]

Autoignition Temp. 1198 F[2]

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower 2.2 Upper 9.2

Solubility

Cold water insoluble[1]

Hot Water

Ethanol soluble[2]

Others: soluble ether, benzene[3]

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

(DOT): other restricted articles, class A; no label, no limit

ICC Classification

Coast Guard Classification

Comments Similar in toxic effects to chlorobenzene. ortho isomer is probably more toxic than meta and para isomers.(2)

References (1) 147

(2) 1066

(3) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name p-Dichlorobenzene (141)

IUC Name 1,4-Dichlorobenzene

Common Names

Structural Formula

$C_6H_4Cl_2$

Molecular wt. 147.01

Melting Pt. 53 C(1)

Boiling Pt. 174 C(1)

Density (Condensed) [illegible] @ [illegible] (1)

Density (gas) 5.08(2) @

Vapor Pressure (recommended 55 C and 20 C)

[illegible] @ [illegible]

@

@

Flash Point

Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water insoluble(1)

Hot Water

Ethanol slightly soluble, hot(1)

Others:

Acid, Base Properties neutral

Highly Reactive with

Compatible with

Shipped in

(AIR) Other restricted cargo, Class A; no limit.

ICC Classification

Coast Guard Classification

Comments

References (1) 1570
(2) 766
(3) 1492

HAZARDOUS WASTES PROPERTIES
WORKSHEET

H. M. Name Trichlorobenzene (436)

IUC Name 1,2,4-Trichlorobenzene

Common Names unsym.-Trichlorobenzene

Structural Formula

$C_6H_3Cl_3$

Molecular Wt. 181.46 Melting Pt. 16.9 C(1) Boiling Pt. 213-213 C(1)

Density (Condensed) 1.4542 @ 20/4 C(1) Density (gas) 6.26(3) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 78.0 C(3) @ @

Flash Point 225 F (C.C.)(3) Autoignition Temp.

Flammability Limits in Air (wt %) Lower Upper

Explosive Limits in Air (wt. %) Lower Upper

Solubility

Cold Water insoluble(1) Hot Water Ethanol slightly(1)

Others: miscible - ether, benzene, carbon disulfide, petroleum ether(2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Coast Guard Classification

Comments steam volatile(2)

References (1) 1570 (C-171)

(2) 1492 (1059)

## HAZARDOUS WASTES PROPERTIES
## WORKSHEET

H. M. Name Chlorobenzene (108)

IUC Name Chlorobenzene

Common Names Phenyl chloride
Chlorobenzol
Monochlorobenzene

Structural Formula

$C_6H_5Cl$

Molecular Wt. 112.56 (1) Melting Pt. -45 C (1) Boiling Pt. 131-2 (2)

Density (Condensed) 1.107 @ 20 C (2) Density (gas) 3.88 (3) @

Vapor Pressure (recommended 55 C and 20 C)

10 mm @ 22 C (2) 40 mm @ 50 C (1) @

Flash Point 28 C (2) Autoignition Temp. 1245 F (3)

Flammability Limits in Air (wt %) Lower Dangerous when exposed to flame (3) Upper

Explosive Limits in Air (wt. %) Lower 1.8 (212 F) Upper 9.6 (302 F) (3)

Solubility

Cold Water insoluble (2) Hot Water Ethanol very soluble (2)

Others: very soluble benzene, chloroform, ether (2)

Acid, Base Properties

Highly Reactive with

Compatible with

Shipped in

ICC Classification Flammable liquid (3) Coast Guard Classification Flammable liquid (3)

Comments

References (1) 1570
(2) 1492
(3) 0766